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Book of Abstracts

11 - New Facilities and Instrumentation

Foreword

In the present booklet we have collected the one-page abstracts of all contributions (invited, oral and poster) accepted at the INPC2013 Conference in the topic

New Facilities and Instrumentation

The submitted abstracts have been divided into the various topics of the Conference following mostly the indication given by the authors. In few cases, where the subject was on the borderline of two scientific areas or it appeared misplaced, the abstracts have been moved to the booklet of the more appropriate topic.

The abstracts are numbered and arranged alphabetically according to the name of the first author. In the parallel and poster sessions of the Conference, each contribution will be identified by the number of the corresponding abstract.

We wish you a pleasant and stimulating Conference.

The Organizing Committee

New Facilities and Instrumentation (NF)

NF 001.	The FARCOS project. First characterization of CsI(Tl) crystals from FARCOS array using charged particles beams at LNS. *L.Acosta, F. Amorini, L. Auditore, R. Bassini, C. Boiano, G. Cardella, M.B.Chatterjee, A.Chbihi, M. D'Andrea, E. De Filippo, L. Francalanza, S. Gianì, A.Grimaldi, C. Guazzoni, E.Henry, E. La Guidara, G. Lanzalone, I. Lombardo, D. Loria, P. Marini, G. Marquínez-Durán, I. Martel, T. Minniti, E. Morgana, S. Nyibule, A. Pagano, E.V. Pagano, M. Papa, G.Passaro, S. Pirrone, G. Politi, F. Porto, L. Quattrocchi, N. Rafal, F. Riccio, F. Rizzo, P.Russotto, G. Saccà, A.M. Sánchez-Benítez, U. Schroeder, J.A. Duenas, S. Santoro, C.Spitaels, A. Trifirò, M. Trimarchi, G. Verde, M. Vigilante, P. Zambon* Contact email: *luis.acosta@dfa.uhu.es*
NF 002.	Turkish accelerator center proton accelerator technical design *Baki Akkus, Yesim Öktem, Latife Sahin , Emel Algin and Metin Yilmaz* Contact email: *akkus@istanbul.edu.tr*
NF 003.	Simulation results of the CALIFA BARREL calorimeter and prototypes *H. Alvarez-Pol, P. Cabanelas, D. Cortina, P. Díaz Fernandez, D. Galaviz, E. Fiori, E. Nacher, B. Pietras, D. Savran, P. Teubig* Contact email: *hector.alvarez@usc.es*
NF 004.	A MAPS-based Micro-Vertex Tracker for the CBM Experiment *S. Amar-Youcef, N. Bialas, M. Deveaux, Q. Li, I. Fröhlich, M. Koziel, B. Milanovic, C. Müntz, B.Neumann, C. Schrader, J. Stroth, T. Tischler, R. Weirich and M. Wiebusch* Contact email: *j.stroth@gsi.de*
NF 005.	PIPERADE: A high-capacity Penning trap based isobar separator for SPIRAL2/DESIR *P. Ascher, B. Blank, K. Blaum, P. Dupré, M. Gerbaux, S. Grévy, H. Guérin, M. Heck, D. Lunney and S. Naimi* Contact email: *pauline.ascher@mpi-hd.mpg.de*

NF 006.	Fast Detectors for TOF system of the MPD expirement *V.A.Babkin, O.I. Batenkov, V.M.Golovatyuk, S.P.Lobastov, V.A.Petrov, M.M.Rumyantsev, A.V.Shipunov, A.V.Shutov, I.V.Slepnev, V.M.Slepnev, A.S. Veschikov, S.V.Volgin, V.I.Yurevich* Contact email: *mikhail.rumyantsev@yandex.ru*
NF 007.	Layout of the detector systems of the MPD project *V.A.Babkin* Contact email: *babkin@nrmail.jinr.ru*
NF 008.	Performances of under-depleted silicon detectors irradiated with heavy-ions *S.Barlini* Contact email: *barlini@fi.infn.it*
NF 009.	High-precision mass spectrometry at the research reactor TRIGA Mainz *T. Beyer, K. Blaum, M. Block, Ch. E. Düllmann, K. Eberhardt, M. Eibach, Sz. Nagy, W. Nörtershäuser, D. Renisch, and C. Smorra* Contact email: *beyert@uni-mainz.de*
NF 010.	ALPI Setup as the SPES Accelerator of Exotic Beams *G. Bisoffi, G. Bassato, S. Canella, B. Chalykh, M. Comunian, M. Giacchini, A. Facco, A. Galatà, A. Pisent, M. Poggi, A. Porcellato* Contact email: *bisoffi@lnl.infn.it*
NF 011.	Agata modules as Compton polarimeters for the measurement of gamma-ray linear polarisation *P.G. Bizzeti, P. Sona, D. Bazzacco, E. Farnea, C. Michelagnoli, A.M. Bizzeti-Sona, G. de Angelis, A. Gadea, A. Gottardo, S. Lunardi, S.M. Lenzi, B. Melon, R. Menegazzo, D. Mengoni, A. Nannini, D.R. Napoli, A. Perego, F. Recchia, E. Sahin, J.J. Valiente–Dobon, C.A. Ur* Contact email: *melon@fi.infn.it*
NF 012.	Hypernuclear Physics studies of the PANDA experiment at FAIR *S. Bleser, F. Iazzi, J.Pochodzalla, K. Rittgen, C. Sahid, A. Sanchez Lorente, M. Steinen, J. Gerl, I. Kojouharov* Contact email: *a.sanchez@gsi.de*

NF 013.	ISOLDE upgrade: HIE-ISOLDE *M. J. G. Borge* Contact email: *mgb@cern.ch*
NF 014.	The european FAZIA initiative: a high performance digital telescope array for heavy ion studies *R. Bougault, G. Casini and G. Poggi* Contact email: *casini@fi.infn.it*
NF 015.	Tracking with Straw Tubes in the PANDA experiment *M. Bragadireanu, D. Pietreanu, M. Idzik, D. Przyborowski, P. Kulessa, K. Pysz, J. Biernat, S.Jowzaee, G. Korcyl, M. Palka, P. Salabura, J. Smyrski, D. Bettoni, E. Fioravanti, I. Garzia, M.Savriè, P. Gianotti, V. Lucherini, E. Pace, M. Mertens, H. Ohm, S. Orfanitski, J. Ritman, V.Serdyuk, P. Wintz, S. Dobbs, A. Tomaradze, G.L. Boca, S. Costanza, P. Genova, L. Lavezzi, P.Montagna, A. Rotondi, S. Spataro* Contact email: *paola.gianotti@lnf.infn.it*
NF 016.	The High resolution ISOBARIC separator of the SPES project *L. Calabretta, M. Comunian* Contact email: *Michele.comunian@lnl.infn.it*
NF 017.	Characterization of Large Volume 3.5" x 8" $LaBr_3$:Ce Detectors for the HECTOR$^+$ array *F.Camera, A. Giaz, L.Pellegri, S. Riboldi, N. Blasi, C. Boiano, A.Bracco, S. Brambilla, S. Ceruti, S.Coelli, F.C.L. Crespi, M.Csatlòs, A. Krasznahorkay, J.Gulyàs, S.Lodetti, S. Frega, B. Million, L.Stuhl, and O.Wieland* Contact email: *franco.camera@mi.infn.it*
NF 018.	The 12 GeV Upgrade of CEBAF – a Status Report on Its Realization and Its Evolving Physics Program *Lawrence S. Cardman* Contact email: *cardman@jlab.org*
NF 019.	A compact neutron-gamma spectrometer *D. Cester, G. Nebbia, L. Stevanato, F. Pino, L. Sajo-Bohus, G. Viesti* Contact email: *luca.stevanato@gmail.com*

NF 020.	A Plastic Scintillator for Pulse Shape Discrimination *D. Cester, G. Nebbia, L. Stevanato , G. Viesti* Contact email: *dcester@pd.infn.it*
NF 021.	SIMONE: Tool for Data Analysis and Simulation *V. Chudoba, P. Papka, S. Sidorchuk, S. Baraeva, B. Hnatio, P. Jalůvková, P. Sharov, R. Slepnev* Contact email: *chudoba@jinr.ru*
NF 022.	The AGATA experimental campaign in GANIL *Emmanuel Clement and Silvia M. Lenzi* Contact email: *clement@ganil.fr*
NF 023.	Research and development on materials for the SPES target *S. Corradetti, A. Andrighetto, M. Manzolaro, D. Scarpa, J. Vasquez, M. Rossignoli, A. Monetti, G. Prete* Contact email: *stefano.corradetti@lnl.infn.it*
NF 024.	Identification of light particle by means of pulse shape analysis *J.A. Dueñas, M. Assie, D. Mengoni* Contact email: *jose.duenas@dfa.uhu.es*
NF 025.	Three new renal simulators for use in nuclear medicine *M. A. Dullius, M. G. Fonseca, M. S. B. Gonçalves, C.J. Cunha, D. N Souza* Contact email: *divanizi@gmail.com*
NF 026.	Kaon Tagging at 0° Scattering Angle for High-Resolution Decay-Pion Spectroscopy *A.Esser* Contact email: *aesser@kph.uni-mainz.de*
NF 027.	The AGATA Demonstrator at LNL *E.Farnea* Contact email: *farnea@pd.infn.it*

NF 028.	Laser Spectroscopy of RI atoms stopped in Superfluid Helium *T. Furukawa, T. Fujita, T. Wakui, X.F. Yang, K. Imamura, Y. Yamaguchi, H. Tetsuka, Y. Tsutsui, Y. Mitsuya, Y. Ichikawa, Y. Ishibashi, N. Yoshida, H. Shirai, Y. Ebara, M. Hayasaka, S. Arai, S. Muramoto, A. Hatakeyama, M. Wada, T. Sonoda, Y. Ito, T. Kobayashi, S. Nishimura, M. Nishimura, Y. Kondo, K. Yoneda, S. Kubono, Y. Ohshiro, H. Ueno, T. Shinozuka, T. Shimoda, K. Asahi and Y. Matsuo* Contact email: *takeshi@tmu.ac.jp*
NF 029.	NEDA: NEutron Detector Array for spectroscopy studies *A.Gadea* Contact email: *andres.gadea@ific.uv.es*
NF 030.	Characterization of a segmented-detector prototype for particle detection in nuclear physics *M. Gelain, D. Mengoni* Contact email: *michele.gelain@studenti.unipd.it*
NF 031.	Highly sensitive bolometers for rare alpha decay studies *L. Gironi* Contact email: *luca.gironi@mib.infn.it*
NF 032.	The external scanning microbeam facility at Labec, Florence: status and perspectives *L. Giuntini, M. Massi, F. Taccetti, S. Calusi, G. Calzolai, L.Carraresi, L. Castelli, M.Chiari, C. Czelusniak, M.E. Fedi, N. Finetti, N. Gelli, F. Lucarelli, P.A Mandò, A.Mazzinghi, L. Palla* Contact email: *giuntini@fi.infn.it*
NF 033.	The pulse beam facility at LABEC: status and perspectives *L. Giuntini, M. Massi, F. Taccetti, S. Calusi, G. Calzolai, L. Carraresi, L. Castelli, M.Chiari, C. Czelusniak, M.E. Fedi, N. Finetti, N. Gelli, F. Lucarelli, P.A Mandò, A.Mazzinghi, L. Palla* Contact email: *giuntini@fi.infn.it*
NF 034.	Study of DSSSD detector response in the interstrip region using a proton microbeam *L. Grassi, D. Torresi, L. Acosta, P. Figuera, M. Fisichella, V. Grilj, M. Jakšić, M. Lattuada, T. Mijatović, M. Milin, L. Prepolec, N. Skukan, N. Soić, V. Tokić, M. Uroić* Contact email: *laura.grassi@irb.hr*

NF 035.	Radioactive ion beam research at ACCULINNA and future ACCULINNA-2 facilities *L. V. Grigorenko* Contact email: *lgrigorenko@yandex.ru*
NF 036.	A helium cryostat for laser spectroscopy of RI atoms in superfluid helium *K. Imamura, T. Furukawa, T. Wakui, X. F. Yang, T. Fujita, Y. Yamaguchi, H. Tetsuka, Y. Mitsuya, Y. Tsutsui, Y. Ebara, M. Hayasaka, S. Arai, S. Muramoto, Y. Ichikawa, Y. Ishibashi, N. Yoshida, H. Shirai, A. Hatakeyama, M. Wada, T. Sonoda, Y. Ito, H. Odashima, T. Kobayashi, H. Ueno, T. Shimoda, K. Asahi and Y. Matsuo* Contact email: *kimamura@riken.jp*
NF 037.	First Online Mass Measurement with MRTOF Mass Spectrograph *Y. Ito, P. Schury, M. Wada, S. Naimi, T. Sonoda, H. Mita, F. Arai, A. Takamine, K. Okada, A. Ozawa and H. Wollnik* Contact email: *yito@riken.jp*
NF 038.	Design Study of 10 kW Direct Fission Target for the RISP Project *D.Y. Jang, K. Tshoo, H.J. Woo, B.H. Kang, G.D. Kim, Y.K. Kim, W.J. Hwang* Contact email: *tshoo@ibs.re.kr*
NF 039.	Present Status of the KEK Isotope Separation System *S.C. Jeong* Contact email: *sunchan.jeong@kek.jp*
NF 040.	The new multipurpose external beamline at the CNA for nuclear physics experiments *M.C. Jiménez-Ramos, Y. Morilla, J. García-López* Contact email: *mcyjr@us.es*
NF 041.	Design of Beam Transport system of ISOL Facility to deliver intense and high purity n-rich RI beam at RAON *B.H.Kang, H.J. Woo, K.H. Tshoo, D.Y. Jang, W.J. Hwang, C.C.Yun, Y.K. Kim, and S.C. Jeong* Contact email: *madhya@ibs.re.kr*
NF 042.	Neutron and Gamma-ray Detection using a Cs_2LiYCl_6 Scintillator *N. Khan, R. Machrafi* Contact email: *nafisah.khan@uoit.ca*

NF 043.	RAON neutron science facility design for measuring neutron-induced cross-section *Jae Cheon Kim, Jae Bum Son, Gi Dong Kim, Yong-Kyun Kim* Contact email: *jaecheon@ibs.re.kr*
NF 044.	Facility for Heavy Ion Collision Experiment at RAON *Young Jin Kim, D. G. Kim, G. D. Kim, Y. H. Kim, Y. Kim, Y. K. Kim, Y. K. Kwon, C. C. Yun, B. Hong, K. S. Lee, E. J. Kim, J. K. Ahn, H. S. Lee* Contact email: *yjkim@ibs.re.kr*
NF 045.	Technical design studies of Large Acceptance Multipurpose Spectrometer (LAMPS) at RAON *Youngjin Kim, D.G.Kim, G.D.Kim, Y.H.Kim, Y.J.Kim, Y.K.Kim, Y.K.Kwon, C.C.Yun, B.Hong, K.S.Lee, E.J.Kim, J.K.Ahn, H.S.Lee* Contact email: *proyjkim@gmail.com*
NF 046.	The status of new fragment separator ACCULINNA-2 project and the first day experiments *S.A. Krupko* Contact email: *krupko@jinr.ru*
NF 047.	A new neutron detector with a high position resolution for the study of the (p, pn) reaction on rare isotopes *Y. Kubota, M. Sasano, T. Uesaka, M. Dozono, M. Itoh, S. Kawase, M. Kobayashi, C. S. Lee, H. Matsubara, H. Miya, S. Ota, K. Sekiguchi, T. Taguchi, T. L. Tang, H.Tokieda and T. Wakui* Contact email: *kubota@cns.s.u-tokyo.ac.jp*
NF 048.	Perspectives and upgrade of ALICE at the LHC *Christian Kuhn* Contact email: *kuhn@iphc.cnrs.fr*
NF 049.	Design of KOBRA (Korea Broad Acceptance Recoil Spectrometer and Apparatus) at RAON accelerator complex *Y. K. Kwon, Y. K. Kim, G. D. Kim, C. C. Yun, Y.J.Kim, J. S. Park, C-. B. Moon, C.S.Lee, J. Y. Moon, K. Y. Chae, S. Kato, S. Kubono and S. C. Jeong* Contact email: *ykkwon@ibs.re.kr*

NF 050.	AFTER@ LHC: A Fixed-Target ExpeRiment at the LHC *J.P. Lansberg, M. Anselmino, R. Arnaldi, S.J. Brodsky, V. Chambert, J.P. Didelez, B. Genolini, E.G. Ferreiro, F. Fleuret, C. Hadjidakis, C. Lorcé, A. Rakotozafindrabe, P. Rosier, I. Schienbein, E. Scomparin, U.I. Uggerhøj* Contact email: *Jean-Philippe.Lansberg@in2p3.fr*
NF 051.	Charged particle identification using pulse shape in FAZIA silicon detectors *N. Le Neindre* Contact email: *leneindre@lpccaen.in2p3.fr*
NF 052.	Beam Line Design of DIAC as a Stable Heavy-Ion Accelerator at KAERI *Cheol Ho Lee, Dae-Sik Changa, Byung-Hoon Oha, Chang Seog Seoc, Sun-Chan Jeongd* Contact email: *chlee4@kaeri.re.kr*
NF 053.	GRETINA results from physics campaign at NSCL *I-Yang Lee* Contact email: *iylee@lbl.gov*
NF 054.	A Detector for Electron-Ion Scattering Experiments at the LHeC *The LHeC Study Group* Contact email: *p.r.newman@bham.ac.uk*
NF 055.	The LHeC - A High Energy Electron-Ion Collider *The LHeC Study Group* Contact email: *p.r.newman@bham.ac.uk*
NF 056.	KRATTA, a versatile triple telescope array for charged reaction products *J. Łukasik, P. Pawłowski, A. Budzanowski, B. Czech, I. Skwirczyńska, J. Brzychczyk, M. Adamczyk, S. Kupny, P. Lasko, Z. Sosin, A. Wieloch, M. Kiš, Y. Leifels and W. Trautmann* Contact email: *jerzy.lukasik@ifj.edu.pl*
NF 057.	Status of the RFQ Beam Cooler for SPES project at LNL *M. Maggiore, A.M. Porcellato, S. Stark, F. Chirulotto, A. Galatà, A. Dainelli, M. De Lazzari, A. Caruso, A. Longhitano* Contact email: *mario.maggiore@lnl.infn.it*

NF 058.	Recent developments at the ISOL SPES facility *M. Manzolaro, A. Andrighetto, S. Corradetti, D. Scarpa, J. Vasquez, M. Rossignoli, A.Monetti, G. Prete* Contact email: *mattia.manzolaro@lnl.infn.it*
NF 059.	A New Digital Electronics Set-up for Nuclear Physics Experiments *T. Marchi, G. Collazuol, M. Cinausero, F. Gramegna, D. Fabris, V.L. Kravchuk, S. Appannababu* Contact email: *cinausero@lnl.infn.it*
NF 060.	TRACE: a charge-particle detector for the the new RIB facilities *D. Mengoni* Contact email: *daniele.mengoni@pd.infn.it*
NF 061.	ARIEL: TRIUMF's Advanced Rare IsotopE Laboratory *Lia Merminga* Contact email: *merminga@triumf.ca*
NF 062.	A Novel Spin-Light Polarimeter for the Electron Ion Collider *Mohanmurthy Prajwal, Dipangkar Dutta* Contact email: *prajwal@jlab.org*
NF 063.	A unique TAS setup for high multiplicity events at VECC, Kolkata using BaF_2 detectors *G. Mukherjee, Balaram Dey, S. Mukhopadhyay, Deepak Pandit, Surajit Pal, H. Pai and S.R. Banerjee* Contact email: *gopal@vecc.gov.in*
NF 064.	First Beam Production and Commissioning Runs at SPring-8 LEPS2 *N. Muramatsu* Contact email: *mura@lns.tohoku.ac.jp*

NF 065.	Beta-delayed neutron spectroscopy with a specialized ion trap and detector array *S. Padgett, N.D. Scielzo, R.M. Yee, P.F. Bertone, F. Buchinger, S. Caldwell, J.A. Clark, A.Czeszumska, C.M. Deibel, J. Fallis, J.P. Greene, D. Lascar, A.F. Levand, G. Li, E.B.Norman, M. Pedretti, A. Perez Galvan, G. Savard, R.E. Segel, K.S. Sharma, M.G. Sternberg, J. Van Schelt, and B.J. Zabransky* Contact email: *padgett4@llnl.gov*
NF 066.	Ion-optical design of KOBRA at RAON *Junesic Park, Young Kwan Kwon, Chong Cheoul Yun, Gi Dong Kim, Yong-Kyun Kim, and Seigo Kato* Contact email: *ykkwon@ibs.re.kr*
NF 067.	Energy Spread and Emittance Simulation for RISP RFQ Cooler *Young-Ho Park, Ju Hahn Lee, Won Joo Hwang, Gi Dong Kim, Hyung-ju Woo, Yong-kyun Kim* Contact email: *yhpark@ibs.re.kr*
NF 068.	Energy and time characterization of Hamamatsu Photonics silicon photomultipliers *R. Perrino, F. Corsi, R. De Leo, G. Galetta, F. Garibaldi, L. Lagamba, F. Loddo, C. Marzocca, E. Nappi and A. Ranieri* Contact email: *roberto.perrino@le.infn.it*
NF 069.	The transfer RIB lines to the DESIR facility at GANIL-SPIRAL2 *L.Perrot* Contact email: *perrot@ipno.in2p3.fr*
NF 070.	VANDLE-izing North America; First Results from the Versatile Array of Neutron Detectors at Low Energy *W.A. Peters, M. Madurga, S. Paulauskas, R. Grzywacz, J.A. Cizewski, M.E. Howard, A. Ratkiwewicz, B. Manning, J. Blackmon, D.W. Bardayan, M.S. Smith, S. Ilyushkin, P.D. O'Malley, F. Sarazin, T. Baumann, M. Thoennessen, P.A. DeYoung, R.R.C. Clement, E. Stech, M. Wiescher* Contact email: *wapeters@nuclearemail.org*

NF 071.	Prototype testing, characterization and complementary simulations for the forthcoming CALIFA Barrel calorimeter *B. Pietras, H. Alvarez-Pol, D. Cortina, M. Bendel, R. Gernhäuser, D. González Caamaño, T. Le Bleis and M. Winkel* Contact email: *benjamin.pietras@usc.es*
NF 072.	Sailing to the Island of Stability with S3 *J. Piot* Contact email: *piot@ganil.fr*
NF 073.	The SPES project at the INFN- Laboratori Nazionali di Legnaro *G.Prete* Contact email: *prete@lnl.infn.it*
NF 074.	Pellet tracking system for hadron physics experiments *A. Pyszniak, H. Calén, K. Fransson, M. Jacewicz, T. Johansson, Z. Rudy* Contact email: *andrzej.pyszniak@gmail.com*
NF 075.	Target thickness dependence of the Be(p,n) neutron energy spectrum *V. Rakopoulos, M. Lantz, A.Solders, A. Mattera, S. Pomp, D. Gorelov, H. Penttilä, R. Bedogni, A.Gentile, D. Bortot, A. Esposito, P. Andersson, A. Hjalmarsson, J. Valldor-Blϋcher, A. Prokofiev, E. Passoth, S. Rinta-Antila, M.V. Introini, A. Pola* Contact email: *vasileios.rakopoulos@physics.uu.se*
NF 076.	Front-End electronics for the FAZIA project *F.Salomon* Contact email: *salomon@ipno.in2p3.fr*
NF 077.	CEPA: A $LaBr_3$(Ce)/$LaCl_3$(Ce) phoswich array for simultaneous detection of protons and gamma radiation emitted in reactions at relativistic energies *J. Sanchez del Rio, E. Nacher, A. Perea, O. Tengblad, T.Nilson, H. Johansson* Contact email: *jose.sanchez@csic.es*
NF 078.	MARA recoil-mass separator at JYFL – status, instrumentation and performance modelling *J. Sarén, K. Auranen, M. Leino, J. Partanen, J. Tuunanen and J. Uusitalo* Contact email: *jhsaren@jyu.fi*

NF 079.	Status of the SPIRAL2 facility *Hervé Savajols* Contact email: *savajols@ganil.fr*
NF 080.	Studies of neutron-rich isotopes at the CARIBU facility *G. Savard* Contact email*: savard@anl.gov*
NF 081.	The solid state laser system for ionization of the SPES radioactive isotopes *D. Scarpa, A. Tomaselli, A. Andrighetto, S. Corradetti, M. Manzolaro, J. Vasquez, M.Rossignoli, A. Monetti, G. Prete* Contact email: d*aniele.scarpa@lnl.infn.it*
NF 082.	Unique experiments at the frontiers of nuclear physics: the experimental program for the Super-FRS *C.Scheidenberger, S. Gales, H. Geissel, H. Simon, I. Tanihata, M. Winkler* Contact email: *c.scheidenberger@gsi.de*
NF 083.	The tagged photon facility at the MAX IV Laboratory *B.Schroder* Contact email: *bent.schroder@nuclear.lu.se*
NF 084.	Multi-reflection time-of-flight mass spectrograph for extremely fast, high-precision mass measurements *P. Schury, F. Arai, Y. Ito, H. Mita, S. Naimi, T. Sonoda, M. Wada and H. Wollnik* Contact email: *schury@riken.jp*
NF 085.	Progress of the New International Facility FAIR *Boris Sharkov and Guenther Rosner* Contact email*: boris.sharkov@fair-center.eu*

NF 086.	Commissioning of DSSSD silicon detectors for experiments with Radioactive Ion Beams: a comparative study of ASIC and "traditional" electronics *E. Strano, M. Mazzocco, D. Torresi, A. Boiano, C. Boiano, D. Pierroutsakou, P. Di Meo, A. Guglielmetti, M. La Commara, C. Manea, M. Nicoletto, C. Parascandolo, L. Parascandolo, M. Sandoli, C. Signorini, F. Soramel, N. Toniolo, J. Grebosz, D. Filipescu, A. Gheorghe, T. Glodariu, E. Stiliaris, L. Stroe, H. Miyatake, Y. Watanabe, S. Jeong, Y.H. Kim, A. Pakou, O. Sgouros, V. Soukeras, K. Zerva* Contact email: *strano@pd.infn.it*
NF 087.	Direct mass measurement program of exotic nuclei based on the TOF-P-ΔE method *Baohua Sun* Contact email: *bhsun@buaa.edu.cn*
NF 088.	A new facility for very low cross section measurements *G.Terwagne* Contact email: *guy.terwagne@fundp.ac.be*
NF 089.	Development of a Compton Camera for Online Range Monitoring of Laser-Accelerated Proton Beams via Prompt-Gamma Detection *P.G. Thirolf, C. Lang, S. Aldawood, L. Maier, K. Parodi* Contact email: *Peter.Thirolf@physik.uni-muenchen.de*
NF 090.	The Facility for Rare Isotope Beams *M. Thoennessen* Contact email: *thoennessen@nscl.msu.edu*
NF 091.	A new real-time detection system for heavy element research *Yu. Tsyganov, A.Polyakov, A.Voinov* Contact email: *tyura@sungns.jinr.ru*
NF 092.	ALTO, the electron-driven ISOL facility in Orsay: status and perspectives *D. Verney* Contact email: *verney@ipno.in2p3.fr*

NF 093.	The mechanical design of the BARREL section of the detector CALIFA for R^3B-FAIR. *J.A. Vilán, H. Alvarez-Pol, E. Casarejos, I. Durán, P. Izquierdo, P. Yañez* Contact email: *e.casarejos@uvigo.es*
NF 094.	Design, construction and test of the structure of the DEMONSTRATOR of the CALIFA detector for R^3B-FAIR, using carbon-fiber composites. *J.A. Vilán, H. Alvarez-Pol, E. Casarejos, I. Durán, A. Iglesias, P. Izquierdo, P. Yañez* Contact email*: e.casarejos@uvigo.es*
NF 095.	SCRIT Electron Scattering Facility at RIKEN *S. Wang, T. Adachi, T. Amagai, M. Hara, T. Hori, S. Ichikawa, R. Kitazawa, K. Koizumi, K. Kurita, Y. Miyashita, T. Miyamoto, R. Ogawara, T. Ohnishi, T. Suda, H. Takehara, T. Tamae, S. Tamaki, M. Togasaki, K. Yanagi and M. Wakasugi* Contact email: *wshou@riken.jp*
NF 096.	Polarization of a stored beam by spin-filtering *C. Weidemann* Contact email: *c.weidemann@fz-juelich.de*
NF 097.	Detector tests for DESCANT - a neutron array for TRIUMF-ISAC *J. Wong, V. Bildstein, P.E. Garrett, D. Bandyopadhyay, J. Bangay, L. Bianco, B. Hadinia, K.G.Leach, C. Sumithrarachchi, S.F. Ashley, B.P. Crider, M.T. McEllistrem, E.E. Peters, S.W. Yates, J.R. Vanhoy* Contact email: *jwong01@uoguelph.ca*
NF 098.	The Status of RIB Facilities at IMP and Future-Project HIAF *G.Q.Xiao, J.C.Yang, J.W.Xia, Y.He, H.W.Zhao, H.S.Xu, X.H.Zhou, B.W.Wei, W.L.Zhan* Contact email: *xiaogq@impcas.ac.cn*
NF 099.	A control system for the stopping of Rb beams in superfluid helium for nuclear laser spectroscopy of RI atoms *X.F.Yang, T.Furukawa, K.Imamura, H.Tetsuka, Y.Yamaguchi, Y.Tsutsui, T. Fujita, Y.Mitsuya, Y.Ebara, M.Hayasaka, A.Arai, S.Muramoto, Y.Ichikawa, Y. Ishibashi, N.Yoshida, H.Shirai, T.Wakui, T.Kobayashi, A.Hatakeyama, M.Wada, H.Ueno, T.Shimoda, K.Asahi and Y.Matsuo* Contact email: *yangxf@ribf.riken.jp*

NF 100.	SHELS - Separator for Heavy ELement Spectroscopy. First results. *A. Yeremin, A. Isaev, O. Malyshev, A. Popeko, V. Chepigin, A. Svirikhin, A. Lopez-Martens, K. Hauschild, O. Dorvaux* Contact e-mail: *eremin@jinr.ru*
NF 101.	Design of the multi-reflection time-of-flight mass spectrometer for the RAON facility *J. W. Yoon, Y.-H. Park, S. J. Park, G. D. Kim, Y. K. Kim* Contact email: *yoonjw@ibs.re.kr*
NF 102.	Extreme Light Infrastructure - Nuclear Physics (ELI-NP) European Research Center *Nicolae-Victor Zamfir* Contact email: *zamfir@tandem.nipne.ro*
NF 103.	^{8}He Nuclei Stopped in Nuclear Track Emulsion *G. Zarubina and P. I. Zarubin* Contact email: *zarubina@lhe.jinr.ru*

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The FARCOS project. First characterization of CsI(Tl) crystals from FARCOS array using charged particles beams at LNS.

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The construction of a new array to study femtoscopy and multi-particle correlations in heavy-ion collisions at intermediate energies (E/A=20-1000 MeV) has been started at INFN, Sezione di Catania and Laboratori Nazionali del Sud. The project, named FARCOS (Femtoscope ARray for COrrelations and Spectroscopy) is aimed to the development of a detector system with high pixelation capabilities in order to perform high precision measurements of two- and multi-particle correlations. The detector will address topics related to the study of dynamics and the equation of state of asymmetric nuclear matter as well as spectroscopy with both, stable and exotic beams. The expected high angular and energy resolution will allow femtoscopy studies using "imaging" techniques to extract information about the space-time characteristics of emission processes for particles produced during the reaction [1, 2]. The designed array will be characterized by a high flexibility to be used at different facilities (LNS-Catania, GANIL, GSI-FAIR) in order to access information on nuclear matter at different baryonic density regimes where little information is known about the density dependence of the symmetry energy term of EOS. The FARCOS project with its preliminary beam tests will be presented as an open opportunity for further implementations and collaborations. At this point, the characterization of the first detection components it was been done. In the first test for a FARCOS demonstrator interacting with stables beams, the current behaviour of the CsI(Tl) crystal forming the last stage of each cluster composing FARCOS was studied using the CYCLOTRON beams provided by the LNS-Catania facility. During such a test, several details related with electronics and CsI(Tl) crystals were performed. The preliminary results using an analysis at level of pixels show a very acceptable light response uniformity in most of the crystals which will be tested with beams, even in more than 2 cm in deep of each one. Some simulations to approach these experimental results have been generated. The present work describes in detail the experimental results from this initial beam test, complemented with previous studies and a comparison with responses from similar types of radiation detectors.

[1] A. Pagano et al., Nucl. Phys. A 681 (2001) 331c.
[2] G. Verde et al., Phys. Rev. C 67 (2003) 034606.

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TURKISH ACCELERATOR CENTER PROTON ACCELERATOR TECHNICAL DESIGN

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The Proton Accelerator Facility (PAF) will be established as a part of Turkish Accelerator Center (TAC) project. The project is supported by the Turkish State Planning Organization. The aim of this sub project is to construct a proton accelerator facility supplying a proton beam with the energy of 1 GeV. The Proton Accelerator Facility will be constructed in a series of stages including a 3 MeV test stand, a 55 MeV linac which can be extended to 100+ MeV, and then a full 1 GeV proton superconducting linac.

Proton accelerator will be a large-scale scientific user facility optimized for the conditions in Turkey to meet the nation's science and technology needs. The proton accelerator will not only enhance the nation's capability in frontier science to raise country's fundamental research and technology level, but also stimulate the technological development in energy, national defense, and industry. One purpose of proton accelerator facility is to design accelerator driven systems. Energy production with accelerator driven systems by using proton beams with the energy of 1 GeV and a current more than 10 mA is carried out and nuclear waste transmutation can be studied. Protons are also advanced radiation sources for cancer therapy, contributing to the nation's health and medical services. 1 GeV proton beam can be used to produce secondary beams, such as neutrons. Neutron beam is unique and vital for material and life sciences, engineering and industrial areas. The current status of the project and possible application areas of TAC Proton Accelerator Facility will be presented.

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Simulation results of the CALIFA BARREL calorimeter and prototypes

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CALIFA (CALorimeter for the In Flight detection of gamma-rays and light charged pArticles) is an advanced detector of γ-rays and light charged particles devised for R^3B (Reactions with Relativistic Radioactive Beams @ FAIR, Darmstadt), a setup designed for experimental reaction studies with fast, exotic nuclei far from stability, with an emphasis on astrophysics, nuclear structure and dynamics and other applications [1].

The multipurpose character of the CALIFA detector is required to fulfill challenging demands in energy resolution (~5 % at 1 MeV for γ-rays) and efficiency. The fast projectile kinematics produces a large Lorentz boost and broadening; their correction imposes a design with high granularity [2]. Charged particles, e.g. protons of energies up to 300 MeV, should be also identified with an energy resolution superior to 1%. Both features can be satisfied simultaneously by a careful design based on carbon fibre alveolar support structures with a minimum of interposed matter [3]. The detector CALIFA is divided in two well-separated sections, a 'Forward EndCap' and a cylindrical 'Barrel'. The Barrel section, covering an angular range from 43.2 to 140.3 degrees, is based on long CsI(Tl) truncated pyramidal crystals coupled to large area avalanche photodiodes (LAAPDs), attains the requested high efficiency for calorimetric purposes. Several prototypes have been constructed to probe the competence of the concept to reach the requirements, each corresponding to different kinematical regions of the CALIFA detector. The construction of the CALIFA Demonstrator, a 20% of the total detector, has already been initiated, and commissioning experiments are expected for the beginning of 2014 [3].

A particular effort has been devoted to the development and analysis of simulations driving the design of the calorimeter. The Barrel geometry has been carefully implemented in the simulation package R3BRoot [4], including variable thickness of crystal wrapping and carbon fibre supports. A complete characterization of the calorimeter response (efficiency, resolution, evaluation of energy losses and reconstruction) under different working conditions, including several selected physics cases have been realized. Prototypes of different sections of the CALIFA Barrel have been modelled and their response following several experiments performed for the evaluation of the γ-rays and light charged particles detection have been evaluated and compared with the experimental results.

The present report summarizes the outcome of the γ-rays and light charged particles simulated interaction for the entire Barrel section and for the configuration of the prototypes tested in different European installations.

[1] Technical Proposal for the Design, Construction, Commissioning and Operation of R3B, universal setup for kinematical complete measurements of Reactions with Relativistic Radioactive Beams. FAIR-PAR/NUSTAR/R3B, December 2005.
Available in http://www-land.gsi.de/r3b/docu/R3B-TP-Dec05.pdf
[2] H. Alvarez-Pol *et al*, Nucl. Instr. and Meth. Phys. Res. B **266** (2008) 4616 - 4620.
[3]A Technical Report for the Design, Construction and Commissioning of The CALIFA Barrel: The R3B CALorimeter for In Flight detection of γ-rays and high energy charged pArticles.
Available at http://igfae.usc.es/~r3b/documentos/TDR/CALIFA_BARREL_TDR.pdf
[4] Code available at http://fairroot.gsi.de/

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A MAPS-based Micro-Vertex Tracker for the CBM Experiment

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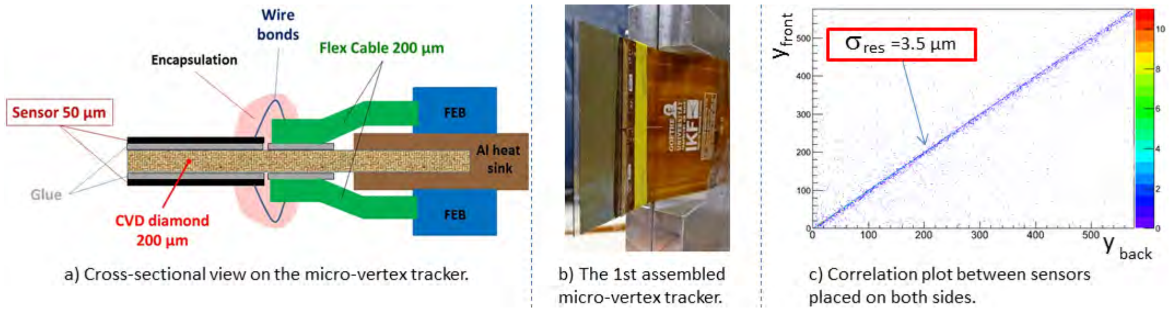
The Compressed Baryonic Matter Experiment (CBM) [1] is a fixed-target experiment aiming at exploring the phase diagram of strongly interacting matter in the regime of highest net-baryon densities with numerous probes, among them open charm (D-mesons). A precise reconstruction of an open charm requires a vacuum compatible Micro Vertex Detector (MVD) with unprecedented properties. Its sensor technology has to feature a spatial resolution of <5 μm, a non-ionizing radiation tolerance of $>10^{13}\mathrm{n_{eq}}/\mathrm{cm}^2$, an ionizing radiation tolerance of 3 Mrad and a readout speed of few 10 μs/frame. The need of prototyping and characterizing the CBM-MVD motivated the construction of a novel, ultra-low mass, high precision, double-sided micro-vertex tracker. Each side contains two identical 50 μm thick CMOS sensors [2]. The sensors are glued to CVD diamond carriers which provide at the same time a mechanical support and efficient heat evacuation.

The device discussed here fulfills two tasks, it is used as a high-precision tracking device and serves as a test site for advanced integration concepts, with the focus on high-performance materials (e.g., CVD diamond). The prototyping phase was addressed with thinned CMOS Monolithic Active Pixels Sensors (MAPS) called MIMOSA-26 [3] and developed at IPHC Strasbourg. The sensors, despite they do not yet meet the requirements of the final MVD with respect to the radiation tolerance and readout time, provide an opportunity to study several aspects important to the CBM-MVD. Due to their size of 21.5x13.8 mm^2 and thickness of 50 μm, MIMOSA-26 are perfectly suited for integration studies including questions of handling and bonding of the ultra-thin and fragile sensors. Moreover, the internal readout architecture of MIMOSA-26 is a precursor of the digital on-chip data sparsification system foreseen for the final sensor design. The pixel pitch of 18.4 μm provides sufficient spatial resolution.

This contribution will discuss important aspects of sensor integration on CVD diamond as well as results obtained during tests with high-energy particle beams from the CERN-SPS, i.e., a spatial resolution, detection efficiency, cluster characteristics, measured as a function of applied threshold, incident angle and temperature.



a) Cross-sectional view on the micro-vertex tracker.

b) The 1st assembled micro-vertex tracker.

c) Correlation plot between sensors placed on both sides.

Figure 1: *A novel micro-vertex tracker for fixed target experiments.*

[1] J.M. Heuser et al.: `http://dx.doi.org/10.1016/j.nima.2006.05.238`
[2] R. Turchetta et al.: `http://dx.doi.org/10.1016/S0168-9002(00)00893-7`
[3] C. Hu-Guo et al.: `http://dx.doi.org/10.1016/j.nima.2010.03.043`

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PIPERADE: A high-capacity Penning trap based isobar separator for SPIRAL2/DESIR

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Important progress has been achieved concerning the knowledge of the structure of the atomic nucleus thanks to the study of exotic nuclei produced in accelerator laboratories. Many phenomena have been evidenced revealing the limits of theoretical models developed with data limited to only stable nuclei. In this framework, the future SPIRAL2 facility [1] (at GANIL in Caen, France) will allow experiments with nuclei which are currently inaccessible. Therefore a large effort is ongoing, led by the nuclear physics community, to develop the equipment which will be used at SPIRAL2. A particular example is the low-energy DESIR facility (Decay, Excitation and Storage of the Radioactive Ions) of SPIRAL2 in which many experimental devices will be installed for decay spectroscopy studies (BESTIOL), laser spectroscopy (LUMIERE) and trap based experiments (DETRAP). For many experiments, highly pure samples of exotic nuclei are needed to perform such studies.

PIPERADE [2] will be a system placed upstream the DESIR hall to purify radioactive beams from undesired contaminants. It will consist of an RFQ (Radio Frequency Quadrupole) to bunch and cool the beam and of a double Penning trap to separate the isobaric species and accumulate the ions of interest. The purified beam will then be sent to the various experiments of the DESIR facility.

Penning traps are widely used as isobaric separators, however, are to date all limited by the amount of isobaric contaminants they can handle, which can not exceed a few hundred at most. The challenge for the present double-Penning trap system consists of being able to accumulate very large amounts of short-lived nuclei (10^6 - 10^7) while maintaining the resolving power necessary for isobar selection of 10^5.

This high-capacity Penning trap will be built in a collaboration between MPIK in Heidelberg, CENBG in Bordeaux and CSNSM in Orsay. First tests measurements and simulations have been performed in order to find an efficient and fast method to separate close species with high relative intensities. In particular, space charge effects have been investigated as well as new excitation schemes.

[1] http://www.ganil-spiral2.eu/spiral2
[2] http://www.cenbg.in2p3.fr/piperade

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Fast Detectors for TOF system of the MPD experiment

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Project NICA/MPD is dedicated to study of hot and dense baryonic matter. The TOF system of MPD is the main detector for particles identification and it is consists of two subdetectors (FFD+MRPC). For separate pion/kaon in the momentum range 0-2.5 GeV/c and proton/kaon in the range 0-4.5 GeV/c it has to have time resolution better than 100 ps [1]. The FFD design is a granulated Cherenkov detector situated near the beam pipe on both side from the interaction region which give the start signal width time resolution better than 40 ps. Second detector is the barrel of fast multi gap RPC detectors on the radius 1.5 m. The MRPC consists of two identical stacks with readout strips and it has time resolution about 55 ps.

[1] A.N. Sissakian, A.S. Sorin, V.D. Kekelidze, et al. “The MultiPurpose Detector – MPD “ to study Heavy Ion Collisions at NICA (Conceptual Design Report) version 1.4 , JINR, Dubna, Russia (2011).

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Layout of the detector systems of the MPD project.

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The detector to explore phase diagram of strongly interacting matter in a high track multiplicity environment has to cover a large phase space, be functional at high interaction rates and comprise high efficiency and excellent particle identification capabilities. Design of the Multi-Purpose Detector (MPD) [1] must meet all these requirements. This presentation provides an overview of all detection systems of the MPD project. The report will present the latest results of prototype testing of detectors and the latest data on progress of the creation of MPD.

[1] A.N. Sissakian, A.S. Sorin, V.D. Kekelidze, et al. “The MultiPurpose Detector – MPD “ to study Heavy Ion Collisions at NICA (Conceptual Design Report) version 1.4 , JINR, Dubna, Russia (2011).

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Performances of under-depleted silicon detectors irradiated with heavy-ions

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Since 2009, the FAZIA collaboration [1] has studied the silicon detectors and their performance in the identification of the nuclear products in heavy ion collisions [2,3] using digital electronics. The identification is obtained by means of the standard ΔE-E correlations and the digital Pulse Shape Analysis (PSA) with fully depleted detectors, mounted in reverse configuration. Very recently tests were performed at the Superconducting Cyclotron of the Laboratori Nazionali del Sud(LNS), where the FAZIA silicon detectors were operated at underdepletion voltages. In particular, the ions produced in dissipative collisions of Kr and Ar ions on different targets were detected with a standard three-stages FAZIA telescope (Si-Si-CsI(Tl) crystal), with the second layer biased at several voltages from fully depletion to heavily underdepletion values. Instead, the first silicon layer was kept at constant full-depletion operation. In this way, event by event, the response of the second layer (namely pulse height information and particle identification) has been tested as a function of the applied voltage for the different ions (Z,A) as a function of their energy loss which is correctly deduced from the ΔE signal.

Comparison between ΔE-E correlations obtained with different applied voltages on the second silicon detector and the impressive effects on the PSA of the not-fully depleted detector will be shown and discussed.

[1] Web site Fazia collaboration (http://fazia.in2p3.fr/spip2/)
[2] L. Bardelli et al., NIMA 654 (2011) 272
[3] S.Carboni et al., NIMA 664 (2012) 251

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High-precision mass spectrometry at the research reactor TRIGA Mainz

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TRIGA-TRAP is a Penning-trap installation for high-precision mass measurements of neutron-rich nuclides produced using the research reactor TRIGA Mainz [1]. Accurate experimental masses of these nuclides are required to test the predictive power of nuclear mass models and to support astrophysical nucleosynthesis calculations. The exotic nuclides are produced by thermal neutron-induced fission of an actinoide target (i.e. ^{235}U, ^{239}Pu, ^{249}Cf) placed in a recoil chamber near the reactor core. An aerosol gas-jet system is used to transport the fission products to an external high-temperature surface ion source, where they are ionized. The ions, accelerated to 30 keV, are then mass-separated in a 90° dipole magnet and the selected species are accumulated in an RF quadrupole cooler-buncher device prior to injection into the double Penning-trap system. In the first trap, the mass-selective buffer gas cooling technique is applied before the ions of interest are transported into the second, high-precision trap, where their mass is measured with the time-of-flight ion-cyclotron-resonance method. Until now, off-line mass measurements of stable or long-lived isotopes have been routinely performed at TRIGA-TRAP. To this end, a laser ablation ion source was developed where small samples down to 10^{14} atoms are sufficient for a mass measurement. The status of TRIGA-TRAP, together with the results of recent mass and Q-value measurements, and the commissioning of the online-coupling will be presented.

[1] J. Ketelaer et al., Eur. Phys. J. A 42, Issue 3, pp 311-317 (2009).

International Nuclear Physics Conference INPC2013: 2-7 June 2013, Firenze, Italy

ALPI Setup as the SPES Accelerator of Exotic Beams

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The SPES project for a national exotic beam facility in Legnaro includes pivotal upgrades of the existing superconducting linac ALPI, to make it appropriate as the RNB secondary beam accelerator. The brand new injector, consisting of an ECR-type charge breeder and a normal conducting RFQ, will be described: it will receive the beam from the high-resolution mass spectrometer following the target-ion-source setup, increase its charge state, pre-accelerate, transport and inject it into ALPI.

Upgrade measures in ALPI in order to improve beam transmission and final energy and to handle low-intensity radioactive beams will be explained, as well as reshuffling of the beam-lines to the experimental stations, where required. The objective is to increase overall transmission to more than 90% and final energy by ~ 20%, so as to reach 10 MeV/u for the reference exotic beam ^{132}Sn.

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Agata modules as Compton polarimeters for the measurement of gamma-ray linear polarisation

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We have investigated the ability of AGATA modules to measure the linear polarisation of gamma rays, exploiting the dependence of the Compton scattering differential cross section on the azimuthal angle. To this aim, partially polarised gamma rays have been produced by Coulomb excitation of the first excited state of ^{104}Pd and ^{108}Pd which deexcite to the ground state by emission of gamma rays of 555.8 keV and 433.9 keV, respectively. The position of the Agata array was chosen to select gamma rays at angles not far from 90 degrees to the beam direction. The azimuthal distributions, with respect to the reaction plane, of the first Compton scattering for a properly selected sample of these gamma rays have been evaluated and compared with the corresponding distribution for the unpolarised 661 keV gammas from a ^{137}Cs source. The instrumental distortions in the measured distributions appear to cancel almost exactly in the ratio $R(\phi)$ of the COULEX data to those of the 661 kev gammas, and a clear signal of linear polarisation becomes apparent. A typical (symmetrised) angular distribution is shown in Fig.1. The amplitude a_2 of the $\cos(2\phi)$ modulation apparent in the figure has been compared to the theoretical linear polarisation of γ rays from Coulomb excitation (calculated with the help of the GOSIA code) to deduce the experimental analysing power, which turns out to be about 45% in both cases. A "theoretical" value of the average analysing power has been deduced from the values calculated, for each of the selected events, as a function of the Compton scattering angle, taking into account the experimental uncertainty on the coordinates of the interaction points. A satisfactory agreement between theoretical and experimental values has been found.

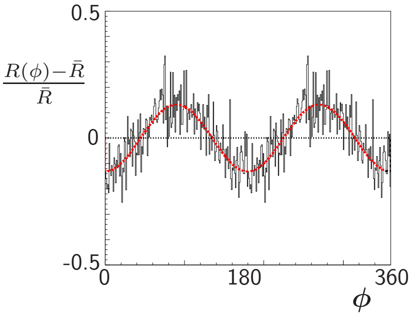

Figure 1: *Deviation of the ratio $R(\phi)$ from its average value $\bar{R}$ for the 555.8 keV γ ray from Coulomb excitation of ^{104}Pd, referred to the 661 keV γ rays. The continuous line is the result of the fit with a function $a_2\cos(2\phi)$ to $[\,R(\phi)-\bar{R}\,]/\bar{R}$.*

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Hypernuclear Physics studies of the PANDA experiment at FAIR

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Hypernuclear research will be one of the main topics addressed by the PANDA experiment at the planned Facility for Antiproton and Ion Research FAIR at Darmstadt (Germany). Thanks to the use of stored $\overline{p}$ beams, copious production of double Λ hypernuclei is expected at the PANDA experiment, which will enable high precision γ spectroscopy of such nuclei for the first time, and consequently a unique chance to explore the hyperon-hyperon interaction.

In comparison to previous experiments, PANDA will benefit from a novel technique to assign the various observable γ-transitions in a unique way to specific double hypernuclei by exploring various light targets. Nevertheless, the ability to carry out unique assigments requires a devoted hypernuclear detector setup. This consists of a primary nuclear target for the production of $\Xi^- + \overline{\Xi}$ pairs, a secondary active target for the hypernuclei formation and the identification of associated decay products and a germanium array detector to perform γ spectroscopy.

Moreover, one of the most challenging issues of this project is the fact that all detector systems need to operate in the presence of a high magnetic field and a large hadronic background. Accordingly, the need of an innovative detector concept will require dramatic improvements to fullfil these conditions and that will likely lead to a new generation of detectors. In the present talk details concerning the current status of the activities related to the detector developments for this challenging programme will be given.

Among these improvements is the new concept for a cooling system for the germanium detector based on a electro-mechanical device. Additionaly, it will be shown how the use of techniques based on pulse digital shape analysis can be applied to restore the energy resolution and line shape of radiation damaged germanium crystals. Furthermore, since the momentum resolution of low momentum particles is crucial for the unique identification of hypernuclei, an analysis procedure for improving the momentum resolution in few layer silicon based trackers is presented.

[1] This research is part of the EU integrated infrastructure initiative Hadron- Physics Project under contract number RII3-CT-2004-506078. We acknowledge financial support from the Bundesministerium für Bildung und Forschung (bmb+f) under contract number 06MZ225I. We also thank the European Community-Research Infrastructure Integrating Activity Study of Strongly Interacting Matter (HadronPhysics2, Grant Agreement n. 227431; SPHERE network) under the Seventh Framework Programme of EU for their support;

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ISOLDE upgrade: HIE-ISOLDE

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The On-Line Isotope Mass Separator ISOLDE at the CERN Proton-Synchrotron Booster (PSB) is a facility dedicated to the production of a large variety of radioactive ion beams for many different experiments in the fields of nuclear and atomic physics, materials science and life sciences. The facility has garnered unique expertise in radioactive beams over the last 45 years. The nuclear physics studies focused at first on fundamental properties (mass, spin, magnetic moments, decay modes) of exotic nuclei using low energy beams of 30-60 keV. New fields of research opened up in 2001 when the Radioactive beam EXperiment, REX, started operation and allowed reaction experiments to be carried out up to 3.1 MeV/u. Unique feature of REX-ISOLDE is that essentially all isotopes produced can be charge-bred and accelerated further. The variety in isotope production is matched by the versatility in ion manipulation so that the physics studies can take place in the energy range from 10^{-6} eV in the case of low-temperature nuclear orientation, to several MeV/u.

In a decade of physics with post-accelerated beams [1] beautiful results have been obtained exploring, by Coulomb excitation with the Miniball HPGe-array the island of inversion at N=20 and shape transitions in extreme neutron rich middle mass nuclei. The heaviest REX-ISOLDE beams of Radon nuclei were employed to investigate shape asymmetric configurations. Elastic, inelastic scattering, and transfer reaction yield important and unique information in the structure of exotic nuclei. Unfortunately the present beam energies at REX-ISOLDE restrict studies to the light nuclei.

The HIE ISOLDE upgrade (HIE stands for High Intensity and Energy), intends to improve the experimental capabilities at ISOLDE over a wide front [2]. The main feature are to boost the energy of the beams, going in steps from currently 3.1 MeV/u via 5.5 MeV/u to finally 10 MeV/u, and to accommodate a roughly fourfold increase in intensity. In addition improvements in several aspects of the secondary beam properties such as purity, ionization efficiency and optical quality are addressed. The experimental equipment will undergo extensive transformation during the long shutdown of the accelerator complex in 2013 to commit to the new Physics challenges [3].

In this contribution recent ISOLDE highlights, the HIE-ISOLDE project and the first proposed experiments will be presented.

[1] P. V. Duppen and K. Riisager, J. Phys. G. Nucl. Part. 38, 02405 (2011).
[2] HIE-ISOLDE: the technical options ed. by M. Lindroos, T. Nilsson, CERN Report, CERN-2006-013
[3] HIE-ISOLDE, the scientific opportunities ed. By K. Riisager, P. Butler, M. Huyse and R. Krcken, CERN Report, CERN-2007-008

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The european FAZIA initiative: a high performance digital telescope array for heavy ion studies

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Fazia is a european collaboration aiming at building a new generation modular array for identification of charged particles in the framework of studies about nuclear collisions above the Coulomb barrier. The base module for the array is a Silicon-Silicon-CsI telescope where the silicon detectors are reverse mounted and scintillators are carefully selected to optimize ion identification via pulse shape. The electronics developed by the collaboration itself features high quality charge and current preamplifiers coupled to a fully digital front-end, mounted under vacuum next to the detectors. The internal front-end is connected via wideband optical links to the DAQ system. The first R&D phase, started few years ago, permitted firstly to determine the main limiting factors affecting ion identification, which are channeling effects [1] and doping non-uniformities in silicons [2] and secondly to identify solutions for improving performances. Original and novel solutions have been thus implemented and tested in prototypes, obtaining unprecedented ion identification capabilities [3-6]. Nowadays, in the second phase, a demonstrator is under construction consisting of about two hundred telescopes arranged in a compact and transportable configuration. The demonstrator is intended to show the discovery potential of such solutions in heavy-ion reaction mechanisms, in particular where the full Z and A identication is needed in a large range, as it is in radioactive-beam induced reactions or for detailed fragmentation studies at Fermi energies. As a matter of fact, some results on isospin dynamics exploiting the high-quality identification capabilities of the FAZIA telescopes have been already achieved [7].

[1] L. Bardelli et al., Nucl. Instr. Meth. A 605, 353 (2009);
[2] L. Bardelli et al., Nucl. Instr. Meth. A 602,501 (2009);
[3] L. Bardelli et al., Nucl. Instr. Meth. A 654, 272 (2011);
[4] S. Carboni et al., Nucl Instr Meth. A 664, 251 (2012);
[5] N. Le Neindre et al., Nucl. Instr. Meth. A 701, 145 (2012);
[6] G. Pasquali et al., Eur. Phys. J. A 48, 158 (2012);
[7] S. Barlini et al., Nucl-ex arXiv:1301.4364 .

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Tracking with Straw Tubes in the $\overline{\mathsf{P}}$ANDA experiment

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The $\overline{\mathsf{P}}$ANDA spectrometer will be built at the FAIR facility at Darmstadt (Germany) to perform accurate tests of the strong interaction through $\bar{p}p$ and $\bar{p}A$ annihilations. The charged particle tracking at $\overline{\mathsf{P}}$ANDA will be done using both solid state and different gasseous detectors. Among the latter, two straw tube detectors will be built [1]. The cylindrical, central straw tube tracker features a high spatial and momentum resolution in a wide range of particle momenta from about 8 GeV/c down to a few 100 MeV/c, together with a particle identification in the momentum region below about 1 GeV/c by using the specific energy-loss method.

A new technique based on self-supporting straw layers with intrinsic wire tension developed for the COSY-TOF straw tracker [2] has been adopted for the $\overline{\mathsf{P}}$ANDA trackers. The straw tubes are assembled and the wire is stretched by 50 g at an overpressure of about 1 bar. Then the tubes are close-packed and glued together to planar double-layers. At the gas overpressure of 1 bar the double-layers maintain the nominal wire tension and become self-supporting. The double layers will be then used to instrument either the Central Tracker, which has a cylindrical geometry, and the Forward Spectrometer that is a planar detector. To read out the straw tube signals, a new ASIC is under development. Each ASIC's channel comprises a charge preamplifier stage, a pole-zero cancelation network, a shaper stage, a tail cancelation network, a discriminator circuit, a baseline holder, a fast differential LVDS output and an analog output. The first prototype of this new device has been produced and used to instrument straw tube modules that have been tested with cosmic rays and proton beams. The design issue of the $\overline{\mathsf{P}}$ANDA straw tubes together with the results of the prototype's tests will be presented.

[1] W. Erni et al., Technical Design Report for the: PANDA Straw Tube Tracker, `arXiv:1205.5441`, In press on EPJ A;
[2] P. Wintz, in Intersections of Particle and Nuclear Physics: 8th Conference CIPANP2003, AIP Conf. Proc. 698-1, 792 (2004);

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The High resolution ISOBARIC separator of the SPES project

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The goal of SPES project is to provide to the LNL users radioactive beams having mass between 20 and 180 amu. Unfortunately, in this mass range nuclei that have the same number of nucleons, but different combination of protons and neutrons number could have mass difference very small, at this scope it has been decided to study a magnetic separator with a mass resolving power of 40000, and a transmission greater than 95%.

In this article the physical design of the separator is reported with the study analysis of pushing the mass resolving power for a standalone user facility at very low energy.

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Characterization of Large Volume 3.5" x 8" LaBr$_3$:Ce Detectors for the HECTOR$^+$ array

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The properties of large volume, cylindrical 3.5” x 8” LaBr$_3$:Ce scintillation detectors coupled to the Hamamatsu R10233-1000SEL photo-multiplier tube (PMT) were investigated. A number of 10 of such detectors constitute the HECTOR$^+$ array which is now located at GSI in the PRESPEC experimental setup.

These crystals are among the largest ones ever produced and needed to be fully characterized from the applicative viewpoint. We tested the detectors using monochromatic γ–ray sources and in-beam reactions producing γ-rays up to 22.6 MeV; we acquired PMT signal pulses and calculated detector energy resolution and linearity of response as a function of γ-ray energy. Two different voltage dividers were coupled to the PMT: the Hamamatsu E1198-26, based on straightforward resistive network design and the “LABRVD”, specifically designed for our large volume LaBr3:Ce scintillation detectors, which also includes active semiconductor devices. Because of the extremely high light yield of LaBr3:Ce crystals we observed that, depending on the choice of PMT, voltage divider and applied voltage, some significant deviation from the ideally proportional response of the detector and some pulse shape deformation may appear. In addition, crystal non-homogeneities and PMT gain drifts can affect the resolution of measurements in case of high energy γ-rays. We also estimated the time resolution of different sized detectors (from 1”x1” up to 3.5”x8”), correlating the results with the intrinsic properties of PMTs and the GEANT simulations of the scintillation light collection process.

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The 12 GeV Upgrade of CEBAF – a Status Report on Its Realization and Its Evolving Physics Program

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The Continuous Electron Beam Accelerator Facility (CEBAF) at Jefferson Lab has provided a unique tool for the study of atomic nuclei by providing intense, cw beams of polarized electrons with energies of up to 6 GeV. A project is now well underway to enhance CEBAF's research capabilities by doubling its beam energy to 12 GeV and constructing an expanded suite of scientific instrumentation. An overview of the project and its status will be presented. In addition, the new science that will become feasible upon completion of this upgrade will be discussed. It includes: the study of hybrid mesons, which involve excited states of glue, to explore the nature of quark confinement; dramatic improvements in our understanding of the QCD structure of the hadrons through both the extension of our knowledge of their parton distribution functions to high xBjorken, where they are dominated by underlying valence quark structure, and a program of nucleon "tomography" via measurements of the Generalized Parton Distributions (GPDs); a broad program of experiments in the physics of nuclei that aims to understand the QCD basis for the nucleon-nucleon force and how nucleons and mesons arise as an approximation to the underlying quark-gluon structure; and precision tests of the Standard Model through parity violating deep inelastic and Møller scattering.

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A compact neutron-gamma spectrometer

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New liquid scintillator, the EJ-309 from Eljen Technology, has been the subject of recent experimental investigations [1,2]. Its interesting characteristics allow the use in several applications where chemical and fire hazards are of particular concern. The pulse shape capability of this detector was recently studied together with the possibility of detecting neutrons in a high gamma ray background as required in homeland security applications [3]. In this work we study a compact and light weight detector obtained coupling an EJ-309 cell to a flat panel H8500 PSPMT. The performances of this detector are compared with a second detector using a traditional linear-focused 12 dynodes PMT. Detector signals are processed by fast digitizer. Energy resolution and pulse shape discrimination (PSD) are equivalent to those obtained with the traditional PMT, being the time resolution slightly worse. Results of tests performed in a magnetic field are shown in Fig. 1. For traditional PMT the signal decreases strongly as the magnetic field increases, at the same time the energy resolution deteriorates from 5% to 11%. Using H8500 PMT the signal reduction is only within 20% up to 250 Gauss.

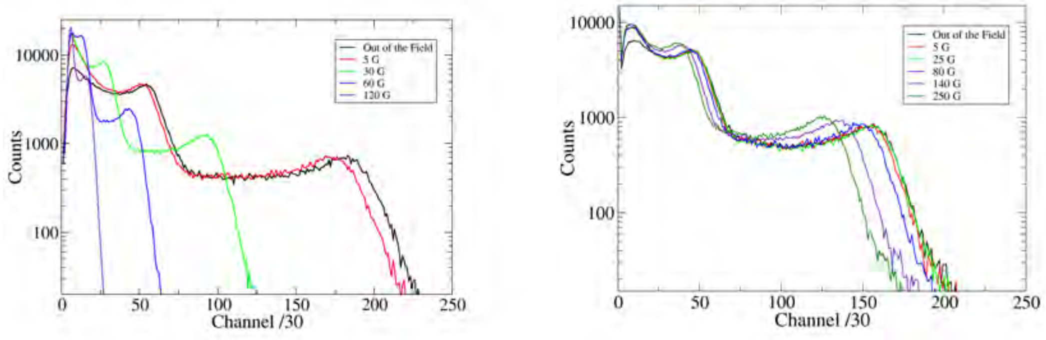

Figure 1: *Measurements with a ^{22}Na in magnetic field. Left panel traditional PMT, right panel Flat PMT.*

The compact detector is now used in a portable, battery operated neutron-gamma compact spectrometer using digital electronics. The first prototype of such spectrometer weighs (including the computer) 8.9 kg with a battery granting a working time of about 2.5 h and will be employed in the field of plasma physics and fusion research.

[1] S.A. Pozzi et al., Nucl. Instr.Meth. A 608 (2009) 310315;
[2] L. Swiderski et al., Nucl. Instr. Meth. A 652 (2011) 330333;
[3] L. Stevanato et al., Nucl. Instr. Meth. A 690 (2012) 96101.

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A Plastic Scintillator for Pulse Shape Discrimination

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In the last years the importance of Homeland Security issues has grown dramatically, following the recent evolutions of international situation. Improvements in radiation detection systems and techniques are under active development. In this field, a central topic is the detection of neutrons and their discrimination from gamma-rays, one of the most used techniques being the Pulse Shape Discrimination (PSD) applied to detector signals. PSD analyzes the shape of the electrical pulse coming from the detector and only a few materials used in scintillators can provide a signal suitable for PSD. Liquid scintillators are the typical choice for PSD applications but their basis is usually toxic and/or flammable and poses safety issues during shipment and handling. Plastic scintillators have been studied for years as a replacement with promising results [1] [2].

In this work we shall present the characterization of a new plastic scintillator with PSD capabilities produced by Eljen Technology. We investigated the discrimination performances of the scintillator as well as other standard parameters as the energy and the time resolution. Our presentation also includes a comparison of the new plastic with other plastic and liquid scintillators used in our recent projects.

[1] N. Zaitseva et al., Nuclear Instruments and Methods in Physics Research A 668 (2012) 88–93
[2] S. Normand et al., Nuclear Instruments and Methods in Physics Research A 484 (2002) 342–350

SIMONE: Tool for Data Analysis and Simulation

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Wide range of experimental studies investigating nuclear reactions at low energies (especially in the field of light exotic nuclei) have many common features. Both, the planning of an experiment and data processing consist of specific steps and number of repeated procedures (e.g. particle and kinematical description, method of Monte Carlo (MC) for reaction simulation, detectors design and particle tracking, calibration procedure, beam diagnostics,...) which should be carried out for almost each experiment.

Tool SIMONE (SIMulations Of Nuclear Experiments), based on ROOT Data Analysis Framework and developed in collaboration of FLNR JINR and iThemba LABS, is intended for physicists planning experiments and analysing experimental data. Goal of the SIMONE framework is to provide a simple system that will be flexible, easy to use, efficient and well documented. It is intended for simulation of arbitrary experiment investigating nuclear reaction. The most significant conditions and physical processes can be taken into account during MC procedure of reactions. User is allowed to use typical particle detectors and create his very own experimental setup. Simulated data should be available in the same format, as it would be from the real experiment, so the next steps of data analysis are identical for both experimental and simulation data. Significant economy of time is expected in the early period of experiment planning and data analysis.

International Nuclear Physics Conference INPC2013: 2-7 June 2013, Firenze, Italy

The AGATA experimental campaign in GANIL

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The GANIL facility, Caen (France), will host the European AGATA germanium array from 2014 to 2015. The AGATA array will be coupled to the VAMOS mass spectrometer and/or to a large number of ancillary detectors that will make the array very versatile.
The structure of nuclei at exteme conditions of excitation energy, spin and isospin will be studied using the high intense stable heavy ions beam delivered by the GANIL cyclotron and the radioactive beams delivered by the SPIRAL1 facility.

In this contribution, the different experimental scenarios will be presented, together with the scientific preliminary program of the AGATA campaign in GANIL

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Research and development on materials for the SPES target

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The SPES project at Laboratori Nazionali di Legnaro (INFN, Italy) is focused on the production of radioactive ion beams. The core of the SPES facility is constituted by the target, which will be irradiated with a 40 MeV, 200µA proton beam (primary beam) in order to produce radioactive species. In order to efficiently produce and release isotopes, the material constituting the target should be able to work under extreme conditions (high vacuum and temperatures up to 2000 °C). Both neutron-rich and proton-rich isotopes will be produced; in the first case, carbon dispersed uranium carbide (UC_X) will be used as a target material to obtain all the desired species, whereas to produce p-rich isotopes, several types of targets will have to be irradiated. The synthesis and characterization of different types of material will be reported. Moreover, the results of irradiation and isotopes release tests on different uranium carbide target prototypes will be discussed

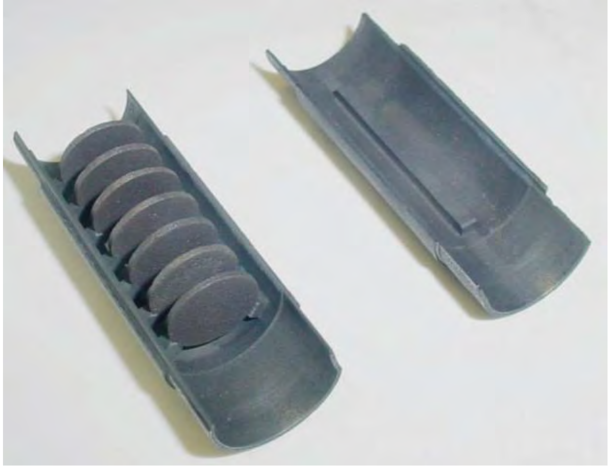

Figure 1: *A uranium carbide target prototype used for irradiation tests*.

[1] A. Andrighetto, L. Biasetto, M. Manzolaro, D. Scarpa, J. Montano, J. Stanescu, P. Benetti, I. Cristofolini, M.S. Carturan, P. Colombo, P. di Bernardo, M. Guerzoni, G. Meneghetti, B. Monelli, G. Prete, G. Puglierin, A. Tomaselli, P. Zanonato, Production of high-intensity RIB at SPES, Nucl. Phys. A 834 (2010) 754c–757c.

[2] S. Corradetti, L. Biasetto, M. Manzolaro, D. Scarpa, A. Andrighetto, S. Carturan, G. Prete, P. Zanonato, D.W. Stracener, Temperature dependence of yields from multifoil SPES target, Eur. Phys. J. A 47 (2011) 119-126.

[3] S. Corradetti, S. Carturan, L. Biasetto, A. Andrighetto, P. Colombo, Boron carbide as a target for the SPES project, J. Nucl. Mater. 432 (2013) 212-221.

International Nuclear Physics Conference INPC2013: 2-7 June 2013, Firenze, Italy

Identification of light particle by means of pulse shape analysis

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Several detector systems being built in Europe such as **G**ASPARD, **H**YDE and **T**RACE (GHT collaboration) are exploiting digital pulse shape analysis (DPSA) techniques aiming to achieve an efficient and low cost particle identification system. Recent FAZIA works [1,2] stress the importance of the quality of the Si detector used, like the resistivity non-homogeneity and the crystallographic orientation. The researches carried about by these groups are pushing the limits of particle discrimination at both ends of the energy spectra going from 1 MeV to few GeV.

The GHT collabaration has achieved particle separation of ^{1,2,3}H at energy of 3 MeV (see Fig. 1-right) by DPSA for particles fully stopped in a 500 μm neutron transmutation doped (NTD) Si detector, in a ^{7}Li + ^{12}C reaction scenario [3]. The DPSA method uses the parameters obtained both from the charge and current pulses generated by a high bandwidth charge sensitive preamplifier. Proton-deuteron identification at energies between 2 MeV and 6 MeV has been studied as a function of the detector working bias (see Fig. 1-left). It has been observed that identification of the H isotopes is better when the detector working bias is close to the depletion voltage rather than over-depletion. Moreover, the presence of high frequency noise on the recorded signals diminished the possibility of identification, although the use of a simple triangular smoothing algorithm counteracted this. Experiments were carried out on both PAD and strip NTD detectors. The results obtained from NTD strip detector indicate that is sufficient to perform the DPSA on signals read from the p-side, and therefore only dedicated electronics may be applied to the p-strips (i.e. fast ADC and low noise preamplifier) leaving the conventional electronics to the n-side.

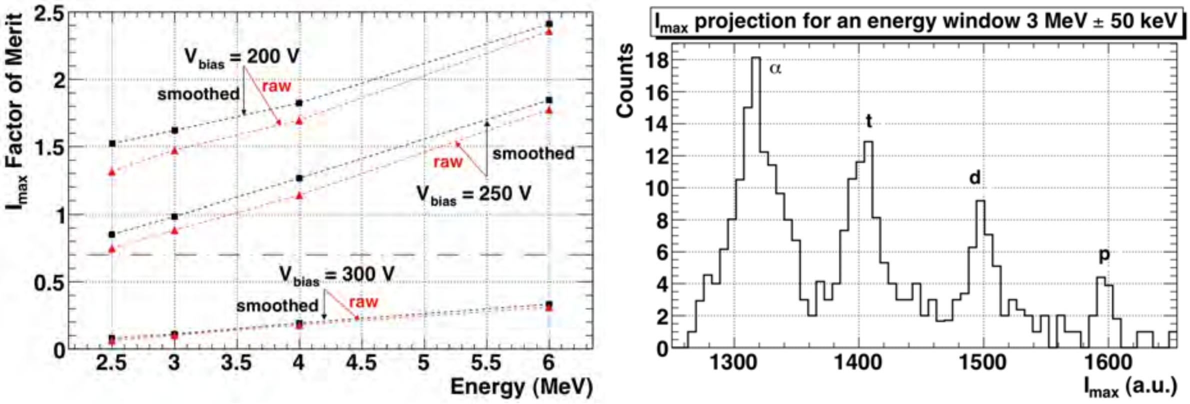

Figure 1: *Light particle identification at energies below* 6 *MeV using the maximum of the current signal. Right, p-d-t and alpha spectrum at* 3 *MeV. Left, influence of the detector bias on the particle identification.*

[1] L. Bardelli et al., NIM A 654 (2011) 272-278.
[2] N. Le Neindre et al., NIM A 701 (2013) 145-152.
[3] J.A. Dueñas et al., NIM A 676 (2012) 70-73.

International Nuclear Physics Conference INPC2013: 2-7 June 2013, Firenze, Italy

Three new renal simulators for use in medicine nuclear

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A quality control program in nuclear medicine covers the verification of the efficiency of all equipment used for diagnosis and for therapy, including the scintillation camera. In this work we develop and evaluate the performance of three renal phantoms: two anthropomorphic and static, and another non-anthropomorphic and dynamic. The static phantoms were used to characterize and evaluate images of static renal scintigraphy (DMSA-99mTc), from images of posterior incidences (POST), right posterior oblique (RPO - 45°), left posterior oblique (LPO) and above. Using these images it is possible to study the processing system response to different concentrations of radionuclides. The static phantoms were made in two different forms. In the first, acrylic was used to mold the kidney human organ. The second was constructed of ABS (*Acrylonitrile butadiene styrene) on 3D printer,* from a computed tomography (TC) of thorax, using the program Slicer. The dynamic renal phantom was built for characterize and evaluate renal dynamic scintigraphic images (DTPA-99mTc), this phantom was constructed of acrylic and an injection pumps it was used to simulate the dynamic renal. With the phantom was possible to evaluate the dynamic response of the processing image system for five forms of renogram. Additionally, it will be possible to performed intercomparisons among renograms obtained in different scintillation cameras and nuclear medicine services. The new static anthropomorphic renal phantoms proved to be efficient for use in measures of variation of radionuclide concentrations. Therefore, new phantoms renal showed effective for use in quality control of scintigraphic cameras and image processing systems.

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Kaon Tagging at 0° Scattering Angle for High-Resolution Decay-Pion Spectroscopy

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At the Mainz Microtron hypernuclei can be studied by (e,e'K) reactions. By detecting the kaon which is emitted in forward direction, with the KAOS spectrometer placed at 0°, reactions involving open strangeness production are tagged. High-resolution magnetic spectrometers are then used to coincidently detect the mono-energetic decay-pions from mesonic two-body weak decays of light hypernuclei at rest.

As a pioneering experiment has shown, the KAOS spectrometer is exposed to a large flux of background particles, mostly positrons from bremsstrahlung pair production. In order to increase the efficiency of kaon identification the KAOS spectrometer was modified to suppress background particles at the cost of a good momentum resolution, which is subordinate for this experiment. This was achieved by placing up to 12 cm of lead absorbers in front of the detectors, in which positrons form electromagnetic showers while the effect on kaons is limited. An additional time-of-flight wall and a new threshold Cherenkov detector help to increase the detection efficiency of kaons.

International Nuclear Physics Conference INPC2013: 2-7 June 2013, Firenze, Italy

The AGATA Demonstrator at LNL

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The experimental conditions at facilities for radioactive ion beams and for high-intensity stable beams are extremely challenging, requiring levels of efficiency and sensitivity, which cannot be reached with conventional 4π arrays of Compton-suppressed high-purity germanium detectors.

The quest for capable instrumentation pursued in the past few years by the AGATA (EU) and GRETA (US) projects implies covering the full solid angle around the target point with electrically-segmented large-volume germanium detectors, maximizing the peak efficiency and peak-to-total ratio through the identification of the interaction points of the photons within the germanium crystals (pulse shape analysis) and a software reconstruction of the trajectories of the individual photons (γ-ray tracking). The major advantage with respect to the present generation arrays is arguably the excellent spectra quality provided up to relativistic beam velocities, where the Doppler broadening correction is dominated by the position resolution within the individual crystals rather than by the finite opening angle of the detectors.

This contribution will focus on the AGATA project and in particular on the subset of the whole array, known as the AGATA Demonstrator. This instrument has operated from 2009 to the end of 2011 at the Laboratori Nazionali di Legnaro, where it was installed at the target position of the magnetic spectrometer PRISMA. Following the commissioning runs in 2009, the AGATA Demonstrator has been exploited in a two-years experimental campaign. A total of 20 PAC-approved measurements were performed, plus 3 in-beam tests, for a grand total of 148 days of beam time. Given the possibilities offered by the coupling with the PRISMA magnetic spectrometer, the campaign has focused mainly on the study of moderately neutron-rich nuclei populated via multinucleon transfer or deep inelastic reactions. However, the proton-rich side of the nuclides chart has been explored as well by coupling AGATA with other complementary devices such as the TRACE silicon detectors or the scintillators of HELENA and HECTOR. The analysis of all of the performed experiments is still in progress and in this contribution the preliminary results of a few selected of them will be presented.

International Nuclear Physics Conference INPC2013: 2-7 June 2013, Firenze, Italy

Laser Spectroscopy of RI atoms stopped in Superfluid Helium

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T. Kobayashi[11], S. Nishimura[2], M. Nishimura[2], Y. Kondo[8], K. Yoneda[2], S. Kubono[12], Y. Ohshiro[12],
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We are developing a new nuclear laser spectroscopic technique to measure nuclear spins and moments of exotic radioisotopes (RIs). In this technique, we use superfluid helium (He II) as a stopping material of energetic RI beams produced in the projectile-fragment separators such as BigRIPS at RIKEN RI Beam Factory. Stopped RI atoms are subjected to in-situ laser spectroscopy in He II. The characteristic features of atoms in He II, e.g. high stopping efficiency for accelerated ion beams, enables us to measure the nuclear spins and moments of the low yield RIs of various elements. We call this method "OROCHI (Optical RI-atom Observation in Condensed Helium as Ion-catcher)."

So far, we have demonstrated the feasibility of OROCHI to deduce the nuclear spins and moments with stable Rb, Cs, Ag and Au isotopes introduced into He II by laser sputtering of sample materials [1]. In a series of the experiments, we observed the hyperfine (Cs and Rb atoms) and Zeeman (Cs, Rb, Ag and Au atoms) spectra using double resonance spectroscopy. From the hyperfine and Zeeman resonance frequencies, we successfully deduced the nuclear spins and magnetic dipole moments, respectively. Note that we can produce large spin polarizations in Cs (90%), Rb (50%), Ag (85%) and Au atoms (85 %) with optical pumping technique in He II. We are going to observe the hyperfine resonance of stable Ag and Au isotopes in the next experiment.

In parallel to the development without an accelerator, experiments with accelerated beams of ^{85}Rb and ^{87}Rb ions (energy: both 66 MeV/u) have been performed at RIKEN. We have observed the Zeeman resonances of introduced Rb isotopes, not only the primary ^{85}Rb (ground state, $I^{\pi}=5/2^{-}$) but also the radioactive ^{84}Rb (ground state, $I^{\pi}=2^{-}$) and ^{84m}Rb (isomer state, $I^{\pi}=6^{-}$) produced by the projectile fragmentation with RIPS separator. The nuclear spin values of ^{84,84m,85}Rb have been obtained from their Zeeman frequencies. The beam intensity of the introduced Rb isotopes is typically 10^4 - 10^5 ions/s in both experiments. The typical yield required for OROCHI is estimated to be 10^3 ions/s with the present setup. This required yield is dominantly limited by the background counts on the photon detector due to huge stray laser light. We are planning to reduce the required yield to as small as 10 ions/s after the improvement of the setup with reducing the stray laser light.

In this presentation, we will discuss the details, present status and the future prospects of the OROCHI, in particular the highlight data of the recent experiments with ion beams of Rb isotopes.

[1] T. Furukawa et al., Hyp. Int. 196, 191 (2010): T. Furukawa et al., PRL 96 095301(2006).

International Nuclear Physics Conference INPC2013: 2-7 June 2013, Firenze, Italy

NEDA: NEutron Detector Array for spectroscopy studies.

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Future studies of exotic nuclei will mainly be performed by using reactions induced by radioactive as well as high-intensity stable heavy ions. The need for efficient neutron detection is not only required in heavy-ion fusion-evaporation reactions close to the proton dripline, but also as ”veto” detectors for suppression of reaction channels with high neutron multiplicity in studies of neutron-rich nuclei.

The new NEutron Detector Array (NEDA) is a collaborative European effort to construct a modern neutron detector array for experiments with stable and radioactive ion beams. The project benefits from the long-standing experience developed with the realization and use of the Neutron Wall [1], a highly efficient medium granularity neutron detector array used in combination with the EUROBALL spectrometer and later with EXOGAM. The new device will be versatile and optimized for the operation with stable beams and second generation radioactive ion-beam facilities (SPES, SPIRAL2, FAIR, etc.). NEDA will be composed of 355 detectors, covering a solid angle of about 2π and will be used as an ancillary detector of AGATA, GALILEO, EXOGAM2 and PARIS. Digital electronics with pulse-shape discrimination capabilities will be used. NEDA will allow the selection of neutron channels in nuclear reactions, providing multiplicity and energy information. It will be realized in different stages, the first one being an upgraded version of the Neutron Wall.

A large effort has been devoted, so far, to the validation of the simulations and test of the future prototypes of NEDA [2,3,4,5]. New detector materials as well as traditional ones have been investigated and characterized, in particular, deuterated liquid scintillators as BC537 and the conventional BC501A. Pulse shape discrimination algorithms have been investigated for both liquid scintillators. A design study of the NEDA array geometry is being performed in order to optimize the granularity, the solid angle coverage in conjunction with the future gamma-ray arrays. In this presentation, the physics domain of NEDA as well as the status of the R&D of the NEDA detector array will be discussed.

[1] Ö. Skeppstedt et al., Nucl. Instr. Meth., A421 (1999) 531.

[2] G. Jaworski et al., Nucl. Instr. Meth., A673 (2012) 64.

[3] A. Pipidis, et al., LNL Annual Report 2010, (2011) 78.
] [4] P.A. Söderström, et al., LNL Annual Report 2011, (2012).

[5] T. Hüyük, et al., LNL Annual Report 2011, (2012).

International Nuclear Physics Conference INPC2013: 2-7 June 2013, Firenze, Italy

Characterization of a segmented-detector prototype for particle detection in nuclear physics

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Nowadays silicon-based detectors have reached an unprecedented level of sophistication which makes such choice an extremely convenient solution for particle-detection application. In fact, this approach benefits of the technological boost due to the revolutionary progress in the microelectronics industry. This has resulted in a large variety of shapes and designs, in the 6-inches wafer technology and with sub-millimetre electrode segmentation, and an outstanding uniformity of the substrate, due to the neutron-transmutation process. Nonetheless, some limitations still affect the design of any common silicon-based detector, among which primarily the radiation damage and the efficiency loss due to the presence of inter-strip and dead-layer.

The present contribution focuses at the investigation of the detection efficiency of an innovative silicon-pad prototype, which is the key element for the construction of the TRACE [1] array, pursued for the SPES [2] facility based at the Legnaro National Laboratories (Italy). The inter-pad size has been estimated by using a commercial 100-MHz-14-bit CAEN digitizer for sampling the signals obtained by an alpha-source scan over the inter-pad region. The energy information, deduced from neighboring segments across the inter-pad zone (fig. [1]), has been correlated both to extract a quantitative value for the inter-pad width and to reconstruct the full energy information. The obtained results have been afterwords compared with a simulation [3] and data from an in-beam experiment [4].

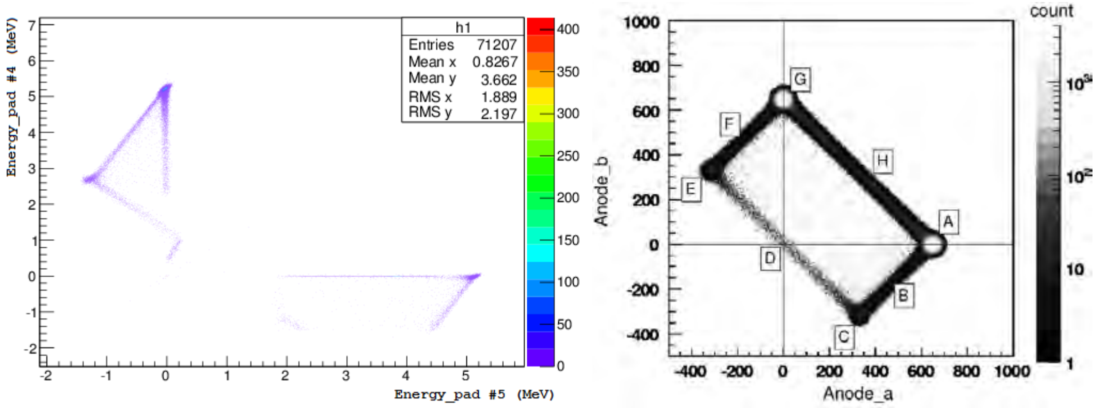

Figure 1: ***Left.***_Correlation matrix for the energy information obtained from two neighboring pads across the inter-pad region. The matrix corresponds to the alpha calibration source position above the inter-pad._ ***Right.*** *The same matrix obtained from simulated results [3].*

[1] A. Gadea et al., NIM A 654 (2011) 8896.
[2] http://web.infn.it/spes/
[3] S. Takeda et al. NIMA 579 (2007) 859-865
[4] D.Torresi et al., submitted to EPJA.

International Nuclear Physics Conference INPC2013: 2-7 June 2013, Firenze, Italy

Highly sensitive bolometers for rare alpha decay studies

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The possibility to have high resolution detectors able to identify background events results very appealing in the study of rare nuclear processes. This goal can be reached by means of scintillating bolometers that, thanks to the simultaneous read-out of the heat and scintillation signals, allow to discriminate different ionizing particles ($\beta/\gamma/\mu$, α and neutron) and achieve background free experiments.

These detectors can be sketched as a calorimetric absorber (a scintillating crystal coupled with a thermometer) and a light detector able to measure the emitted photons. The driving idea of this hybrid detector is to combine the two information available: the heat (i.e. the large fraction of the energy released in the crystal absorber which is converted into phonons) and the emitted scintillation light (i.e. that small fraction of the energy which is converted into photons). Thanks to the different scintillation yield of different particles they can be very efficiently discriminated.

In the study of alpha decays, the scintillating bolometers allow to disentangle alpha peaks from the background due to β, γ, muons and neutrons reaching extremely high sensitivity. With this technique is indeed already been possible to measure rare alpha decays never previously measured as for ^{180}W and ^{209}Bi or improve existing limits as in the case of Pb isotopes.

In particular, we present the results obtained with this technique in the study of ^{209}Bi alpha decay [1]. For the first time, the ^{209}Bi alpha decays to the ground and to the first excited states were unambiguously observed with a BGO scintillating bolometer. This measurement not only add a new experimental information on ^{209}Bi, namely the Branching Ratio between the ground state and the excited state transition, but allowed to measure the rarest alpha decay ever measured proving once more the potentialities of the bolometric technique in the study of rare nuclear processes.

[1] J. W. Beeman et al., Phys. Rev. Lett. 108, 062501 (2012);

International Nuclear Physics Conference INPC2013: 2-7 June 2013, Firenze, Italy

The external scanning microbeam facility at Labec, Florence: status and perspectives

L. Giuntini[1, 2], M. Massi[1, 2], F. Taccetti, S. Calusi[1, 2], G. Calzolai[1, 2], L. Carraresi[1, 2], L. Castelli[2], M. Chiari[2], C. Czelusniak[1, 2], M.E. Fedi[2], N. Finetti[2, 3], N. Gelli[2], F. Lucarelli[1, 2], P.A Mandò[1, 2], A. Mazzinghi[1, 2], L. Palla[2, 4]

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At LABEC (Laboratorio di tecniche nucleari per l'Ambiente e i Beni Culturali of INFN Firenze) we have gradually upgraded our facility by integrating the initial core with complementary techniques. The laboratory, at the beginning constituted by a 2-detector external beam PIXE set-up, exploiting a static milli-beam, was successively developed by making available high resolution probes and a system to raster scan the beam over the sample, thus providing imaging capabilities [1]. Also the available techniques increased with time and we can now exploit external PIGE, BS, FS, IL, IBIC and STIM, which make possible the exploration of fields different from CH [2], such as, for example, Material Science [3], Geology [4] and Environmental Science [5]. Our most recent development is a new technique, the in air broad beam ionoluminescence microscopy, for a nimble discrimination and possibly identification of different minerals in rocks and stone objects [4].

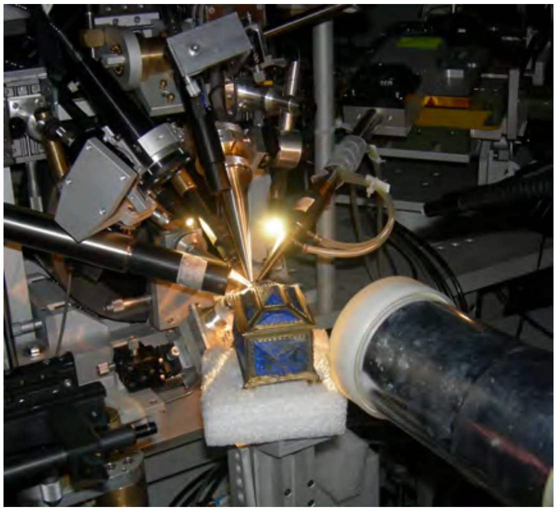

Figure 1: A beautiful XVII century lapis lazuli object at the LABEC external scanning microbeam facility.

[1] L. Giuntini, M. Massi, S. Calusi, (2007), Nucl Instrum Method A, 576:266 – 273,
[2] N. Grassi, L. Giuntini, M. Massi, P.A. Mandò, (2007), Nucl Instrum Method B 256:712 – 718,
[3] S. Lagomarsino, P. Olivero, F. Bosia, M. Vannoni, S. Calusi, L. Giuntini, and M. Massi, Phys. Rev. Lett. 105(23), 233903 (2010),
[4] A. Lo Giudice, A. Re, D. Angelici, S. Calusi, N. Gelli, L. Giuntini, M. Massi and G. Pratesi, Anal Bioanal Chem (2012) 404:277 – 281,
[5] E. Gramigni, S. Calusi, G. Chelazzi, F. Del Greco, G. Delfino, N. Gelli, L. Giuntini, M. Massi and G. Santini, X-Ray Spectrom. 2011, 40, 186–190.

International Nuclear Physics Conference INPC2013: 2-7 June 2013, Firenze, Italy

The pulse beam facility at LABEC: status and perspectives

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At LABEC (Laboratorio di tecniche nucleari per l'Ambiente e i Beni Culturali of INFN Firenze) we have upgraded our DEFEL facility, used to generate packets of ions. The ions can range from protons to oxigens, with energies up to 15 MeV (depending on the ion) ; the number of ions per packet can be selected from < 1 to a few thousand. The repetition rate of the packets can go from single shot to few kHz.

The facility has been upgraded with new slits, providing spatial resolution of the beam of the order of 10 microns. Both an optical imaging system and a beam profile monitor with resolution of a few microns , to be used into the target vacuum chamber, are under construction.

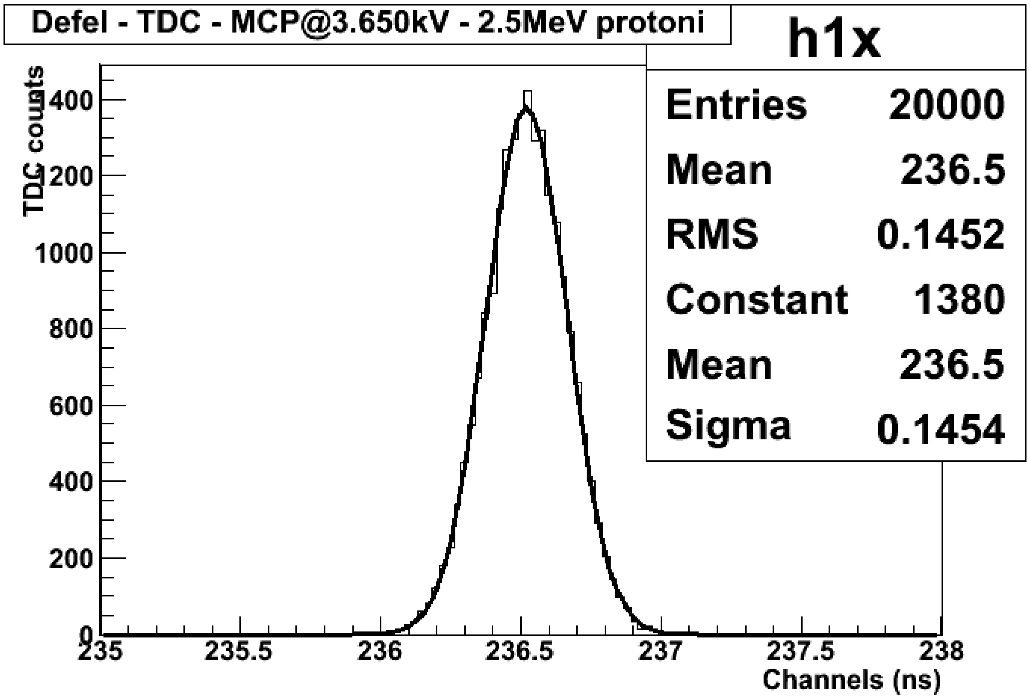

Figure 1: Time definition of beam bunches.

International Nuclear Physics Conference INPC2013: 2-7 June 2013, Firenze, Italy

Study of DSSSD detector response in the interstrip region using a proton microbeam

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M. Lattuada[2,5], T. Mijatović[1], M. Milin[6], L. Prepolec[1], N. Skukan[1], N. Soić[1], V. Tokić[1],
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Double Sided Silicon Strip Detectors (DSSSDs) are widely used silicon detectors having both electrodes (front and back) segmented into mutually orthogonal strips, thus giving information on energy and position of incoming particles. Their segmentation allows to easily cover large solid angles with good granularity, making them especially suitable when measuring angular distributions with low intensity radioactive beams and/or when coincidences between two or more particles are required to fully characterize the final state.

Data from nuclear physics experiments show that the DSSSD efficiency can be affected by anomalous charge collection effects, for ions entering the detector in the interstrip region. This can take place due to the inhomogeneous electric field in the region, to lost charge in dead layers and to different ionization profiles that detected ions may have. When a charged particle hits the interstrip region, effects such as charge sharing and pulse height deficits, as well as inverse polarity pulses on adjacent strips, can occur [1, 2, 3, 4]. A low intensity (~fA) proton microbeam, from the scanning proton microbeam facility of the Ruđer Bošković Institute, was used to probe the behavior of two DSSSDs, 72 µm and 1000 µm thick. The response of these two detectors was studied as a function of the ion hit position with a resolution of 1 µm, with different bias voltages and different proton beam energies (0.8, 1.7, 3, 6 MeV). Results show that the effective width of the interstrip region, which is linked to the detector efficiency, changes with both the beam energy and bias voltage and that dependence on the bias voltage is different for the two detectors. The beam energy dependence remains even for full depletion bias. It is observed for the first time that inverted polarity pulses are generated in the back side strips if protons punch through the detector. Implications for the DSSSD use in nuclear physics experiments are discussed, and new results used to test previously suggested mechanisms of inverted polarity signal generation.

[1] J. Yorkston and A.C Shotter, Nucl. Instr. and Meth. A 262, 353 (1987);
[2] Y. Blumenfeld et al., Nucl. Instr. and Meth. A 421, 471 (1999);
[3] V. Eremin et al., Nucl. Instr. and Meth. A 500, 121 (2003);
[4] D. Torresi et al., Submitted for publication in Nucl. Instr. and Meth.

International Nuclear Physics Conference INPC2013: 2-7 June 2013, Firenze, Italy

Radioactive ion beam research at ACCULINNA and future ACCULINNA-2 facilities

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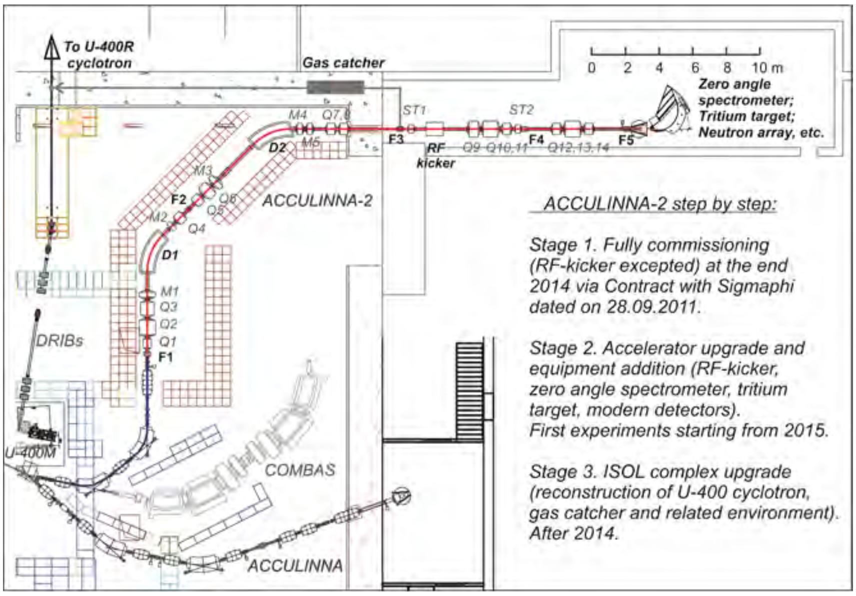
ACCULINNA is in-flight fragment separator based on U-400M cyclotron at Flerov Laboratory of Nuclear Reactions (FLNR, JINR, Dubna, Russia). In the recent years there was an active line of radioactive ion beam research at FLNR dealing with light dripline systems. Novel results were obtained for such isotopes as ^{5}H [1-3], ^{7}H [4], ^{8}He [5], ^{9}He [6], ^{26}S [7], ^{6}Be [8], and ^{10}He [5,9]. The major results of these studies are presented and discussed both from experimental and theoretical points of view focusing on continuum properties, studies of specific correlations, and connection between theory and experiment.

The FLNR is now in the process of massive upgrade which is named DRIBS-3 initiative (Dubna Radioactive Ion BeamS). In the framework of this initiative the ACCULINNA facility is currently being replaced with much more powerful ACCULINNA-2 fragment separator (commissioning planned for 2015). The ACCULINNA is planned to be converted to applied activities (biology and material research). We discuss the characteristics and scientific objectives of the ACCULINNA-2 facility and formulate the general scientific program for the first years of operation.



ACCULINNA-2 step by step:

Stage 1. Fully commissioning (RF-kicker excepted) at the end 2014 via Contract with Sigmaphi dated on 28.09.2011.

Stage 2. Accelerator upgrade and equipment addition (RF-kicker, zero angle spectrometer, tritium target, modern detectors). First experiments starting from 2015.

Stage 3. ISOL complex upgrade (reconstruction of U-400 cyclotron, gas catcher and related environment). After 2014.

Figure 1: *Schematic view of the ACCULINNA and ACCULINNA-2 fragment separators in the U-400M cyclotron hall. The planned stages of facility construction are given in the legend.*

[1] A.A. Korsheninnikov *et al.*, Phys. Rev. Lett. 87, 092501 (2001).
[2] M.S. Golovkov *et al.*, Phys. Lett. B 566, 70 (2003).
[3] M.S. Golovkov *et al.*, Phys. Rev. Lett. 93, 262501 (2004).
[4] M.S. Golovkov *et al.*, Phys. Lett. B 588, 163 (2004).
[5] M.S. Golovkov *et al.*, Phys. Lett. B 672, 22 (2009).
[6] M.S. Golovkov *et al.*, Phys. Rev. C 76, 021605(R) (2007).
[7] A.S. Fomichev *et al.*, Int. J. Mod. Phys. E 20, 1491 (2011).
[8] A.S. Fomichev *et al.*, Phys. Lett. B 708, 6 (2012).
[9] S.I. Sidorchuk *et al.*, Phys. Rev. Lett. 108, 202502 (2012).

International Nuclear Physics Conference INPC2013: 2-7 June 2013, Firenze, Italy

A helium cryostat for laser spectroscopy of RI atoms in superfluid helium

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Y. Mitsuya[1], Y. Tsutsui[7], Y. Ebara[7],M. Hayasaka[7], S. Arai[1], S. Muramoto[1], Y. Ichikawa[3,9],
Y. Ishibashi[3,8], N. Yoshida[9], H. Shirai[9], A. Hatakeyama[10], M. Wada[3], T. Sonoda[3], Y. Ito[3,8],
H. Odashima[1], T. Kobayashi[11], H. Ueno[3], T. Shimoda[6], K. Asahi[9] and Y. Matsuo[3]

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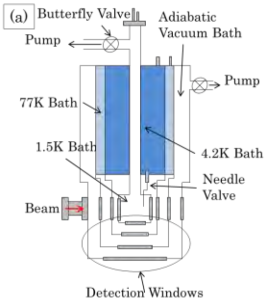
We are developing a new nuclear laser spectroscopic technique called OROCHI[1] (Optical Radioisotope atom Observation in Condensed Helium as Ion-catcher) that can be applied to the study of nuclear structure of short-lived and low-yield unstable nuclei produced at accelerator facilities. we use superfluid helium(He II) as host matrix for stopping accelerated ion beam and perform laser· radio frequency/micro wave(RF/MW) double resonance method to measure Zeeman splitting and hyperfine structure splitting.

In OROCHI, cryostat is a key apparatus for both realizing He II environment and performing laser spectroscopy experiment. In 2010, we carried out experiment using ^{87}Rb beam, we successfully observed florescence of atoms induced by laser light and spin polarization of atoms using optical pumping method. In the next experiment in 2012, to observe double resonance signal from ^{84,85}Rb, it was necessary to install RF/MW generator in the cryostat. After we modified the cryostat suitable for laser spectroscopy experiment, we also have to realize appropriate He II environment for our experiment. In that context, we have developed cooling procedure of the cryostat. According to the cooling procedure, we could achieve stable temperature and pressure of He II condition at 1.79± 0.02K, 12±2Torr respectively. We also evaluated the continuous operation time with a single transfer as 19 hours. Contenious operation time in 2012 is twice as long as that in 2010

We carried out experiment using this cryostat in 2012. We observed RF double resonance of ^{84,85}Rb atoms

In this presentation, we will show details of our cryostat and status during experiment performed in 2012.



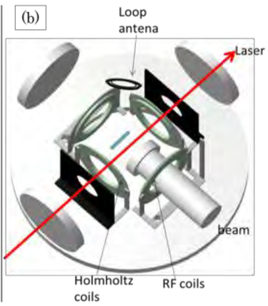


Fig.1 (a) Scematic daiagram of cryostat
Fig.2 (b) Scematic diaiagram of 1.5K bath

[1] T. Furukawa et al., Hyp. Int. 196, 191 (2010)

International Nuclear Physics Conference INPC2013: 2-7 June 2013, Firenze, Italy

First Online Mass Measurement with MRTOF Mass Spectrograph

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Mass measurements of unstable nuclei, providing direct measure of the nuclear binding energy, are invaluable for nuclear structure and nuclear astrophysics. Mass measurements of highly neutron-rich nuclei from Co to Xe, of importance for understanding both the astrophysical r-process and evolution of shell structure, require fast measurement time and high efficiency, due to their typically short lifetimes ($T_{1/2} < 100$ ms) and low production yields.

In order to satisfy such requirements, we have developed a multi-reflection time-of-flight mass spectrograph (MRTOF)[1] as part of the universal slow RI-beam (SLOWRI) facility for low energy nuclear physics[2], as a faster alternative to Penning trap mass spectrometry (PTMS).

Recently we performed the online commissioning experiment of MRTOF with unstable nucleus $^{8}\mathrm{Li}^{+}$($T_{1/2} = 838$ ms), which was produced by projectile fragmentation at RIPS projectile fragment separator and converted them to a low-energy ion beam by the prototype SLOWRI. Figure 1 shows typical ToF spectrum of $^{8}\mathrm{Li}^{+}$. With the ToF of about 8 ms, the mass resolving power of $R_{\mathrm{m}} \approx 148,000$ was achieved. Using $^{12}\mathrm{C}^{+}$ as a reference to determine the mass from the ToF, we obtained the statistical mass uncertainty of $\delta m_{\mathrm{sta}} = 1.5$ keV, corresponding to the statistical mass precision of $\delta m/m = 2.0 \times 10^{-7}$, with good agreement with the literature value.

We will show the experimental detail as well as the prospect of mass measurements for heavier nuclei.

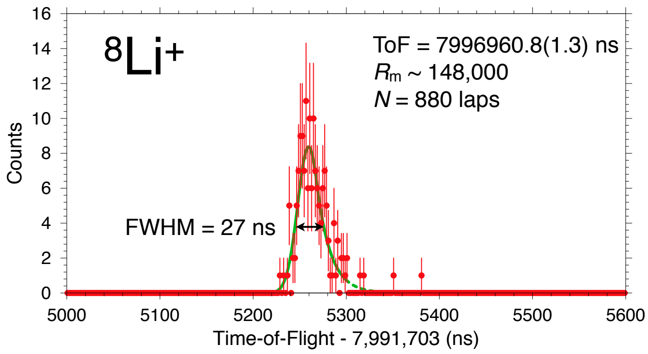

Figure 1: *Typical time-of-flight spectrum for $^{8}Li^{+}$ after 880 laps in the MRTOF.*

[1] P. Schury et al., Eur. Phys. Jour. A 42 (2009) 343;
[2] M. Wada, Nucl. Instr. Meth. Phys. Res. A532 (2004) 40.

International Nuclear Physics Conference INPC2013: 2-7 June 2013, Firenze, Italy

Design Study of 10 kW Direct Fission Target for the RISP Project

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The facility based on fission ISOL (Isotope Separation On-Line) target enables us not only to produce the nuclei with the medium mass neutron-rich region but also to obtain their high production rates. We are developing the ISOL target system, which consists of 1.3 mm-thick uranium-carbide multi-disks and the cylindrical tantalum heater, to be installed in new facility of RISP (Rare Isotope Science Project) in Korea. Figure 1 shows the schematic view of the ISOL target designed. The intense neutron-rich nuclei are produced via the fission process using the uranium carbide targets and a 70 MeV proton beam. The fission rate was estimated to be $\sim 10^{13}$/sec for about 10 kW proton beam. The target system has been designed to be operated at a temperature of ~ 2000 °C so as to improve the release efficiency. The production yields of the neutron-rich isotopes, such as the double magic nucleus ^{132}Sn, are estimated by the Monte Carlo simulation, combining with the simulated results of the thermal analysis and the release efficiency. These results will be presented.

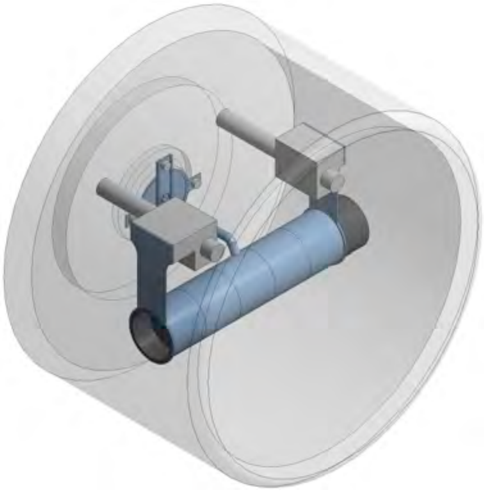

Figure 1: *The schematic view of the 10 kW ISOL target.*

International Nuclear Physics Conference INPC2013: 2-7 June 2013, Firenze, Italy

Present Status of the KEK Isotope Separation System

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The KISS-KEK Isotope Separation System- has been constructed at Nishina Research Center (NRC) of RIKEN to study the decay properties of heavy neutron-rich isotopes with the mass number around A ~ 200 and the neutron magic number of N = 126 for the astrophysical interest [1]. In the KISS, these isotopes will be produced by multi-nucleon transfer reactions in neutron-rich heavy ion collisions (e.g. ^{136}Xe projectile on ^{198}Pt target). It consists of a gas-cell system for thermalizing (stopping and neutralizing) and fast-transporting those reaction products, a laser ionization system for the resonant ionization at the gas-cell exit, and a mass-separator system followed by a detection system for their decay spectroscopy. Therefore, the KISS will allow us to study a single isotope produced by a weak reaction channel under an unprecedentedly low background environment.

The off-line test of the KISS has been finished [2, 3]; the differential pumping system essential for fast transportation of trace elements in the gas cell, the laser ionization of atoms evaporated from filaments in the gas cell, and the mass resolving power of the mass separator. By injecting the beam of ^{56}Fe from the RIKEN Ring Cyclotron (RRC), the on-line test of the KISS has been just started to investigate the overall efficiency and selectivity as a function of the beam injection rate.

In the conference, after a brief introduction of the physics goal of the KISS, the performance of the KISS as a mass separation system will be discussed.

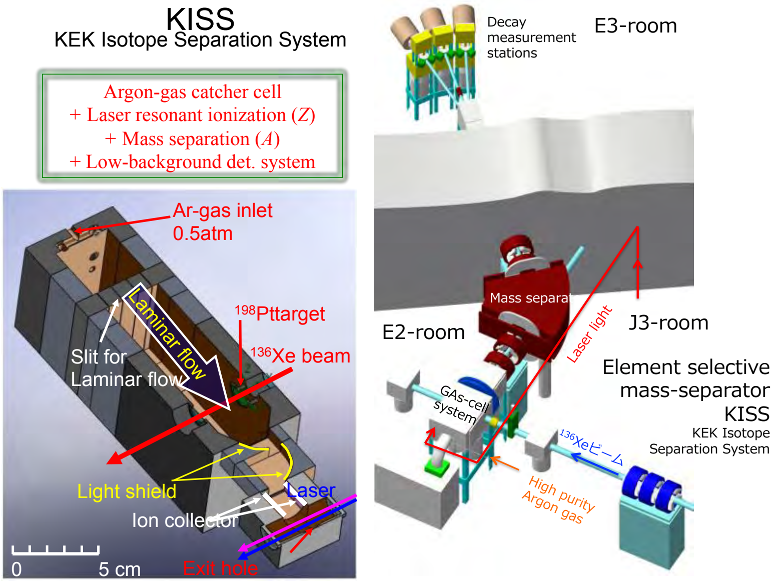

Figure 1: *Schematic layout of the KISS (right) and the gas-cell installed in the vacuum chamber of the gas-cell system (left).*

[1] S.C. Jeong et al., KEK Report 2010-2.
[2] Y. Hirayama et al., RIKEN Accel. Prog. Rep. 44 (2011) 25; 45 (2012) 152.
[3] H. Ishiyama et al., RIKEN Accel. Prog. Rep. 45 (2012) 151.

* KISS collaboration: Y. Hirayama, N. Imai, H. Ishiyama, H. Miyatake, M. Oyaizu, Y.X. Watanabe (KEK), Y.H. Kim (SNU), Momo Mukai (Tsukuba Univ.), Y. Mtauo, T. Sonoda, M. Wada (RIKEN), M. Huyse, Yu. Kudriavtsev, P. Van Duppen (KUL)

International Nuclear Physics Conference INPC2013: 2-7 June 2013, Firenze, Italy

The new multipurpose external beamline at the CNA for nuclear physics experiments

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The 18/9 compact cyclotron installed in the Centro Nacional de Aceleradores (CNA) is nowadays the highest proton/deuteron energy source in Spain. From the first, it has been commonly used to create short lifetime radioisotopes for Positron Emission Tomography (PET). In addition, since one of the target ports is equipped with a beam transport line, a wide range of experiments can be performed in different fields of Nuclear Physics. Initially, only the in-vacuum work line was available, but now this accelerator has been supplemented with a new versatile external beamline, allowing the beam extraction to the air.

In this work, we will describe the main elements of the line and the methodology for some multipurpose applications in our facility. Although Particle Induced X-ray Emission (PIXE) analyses have been also carried out [1, 2], we will present the experimental details for several irradiation tests: radiation effects on electronic devices for space applications, functional test of non interceptive beam profile monitors, the study of radiation hardness in optical fiber sensors and magnets to be used in High Energy Physics facilities.

These studies have been done in collaboration with various Spanish institutions like Universidad Carlos III de Madrid, INTA, CIEMAT, IFCA, Universidad de País Vasco and ESS Bilbao.

Figure 1: *Example of external beamline* set-up *for i*rradiation test.

[1] J. García López, I. Ortega-Feliu, Y. Morilla, A. Ferrero, Nucl. Instrum. Methods Phys. Res., Sect. B 266 (2008) 1583-1586.

[2] Y. Morilla, M.C. Jiménez-Ramos, J. García López, J.A. Labrador, F.R. Palomo, I. Ortega-Feliu, Nucl. Instrum. Methods Phys. Res., Sect. B 273 (2012) 218-221.

International Nuclear Physics Conference INPC2013: 2-7 June 2013, Firenze, Italy

Design of Beam Transport system of ISOL Facility to deliver intense and high purity n-rich RI beam at RAON

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The Rare Isotope Science Project (RISP) in Korea is being undertaken with a goal of construction of world-class Rare Isotope Facility (RAON). The main goal of the Isotope Separation On-Line (ISOL) facility, one of RI facility, is to deliver high quality intense neutron-rich (n-rich) beams to the experimental hall using high power (>10 kW) direct fission target. With this target, the production of 10^{14} fission rate and deliver rate 10^5 ~ 10^9 pps of 80<A<140 mass range to low energy experiment hall are estimated. To provide various element species, FEBIAD, Surface Ionization and Resonance Ionization Laser RI Ion Source are under development. To deliver high purity of RI beam, high performance beam purification systems with mass resolving power over 10,000 and a limit of 6×10^5 background per second are also in development, which is comprised of RF-Cooler, High Resolution Mass Separator, ECR and EBIS charge breeder and charge state separator. Figure 1 shows the schematic view of ISOL target area and beamline. The current status of technical design of ISOL facility will be presented.

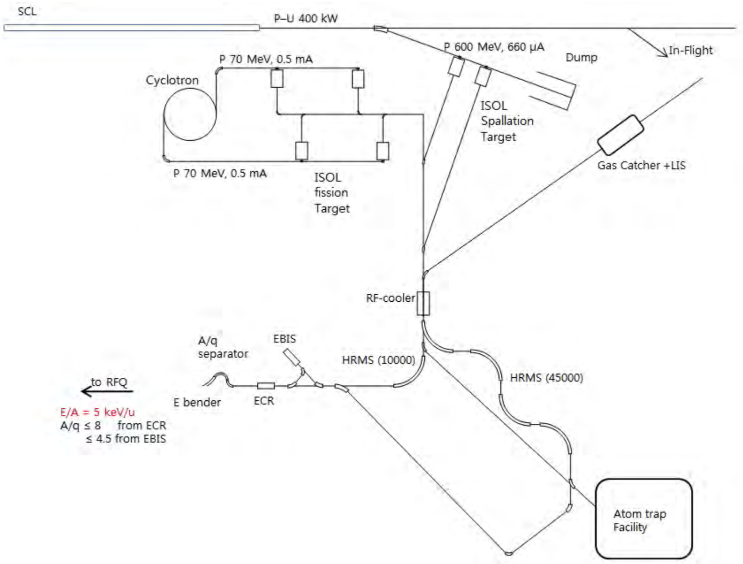

Figure 1: *The schematic view of ISOL target area and beamline.*

International Nuclear Physics Conference INPC2013: 2-7 June 2013, Firenze, Italy

Neutron and Gamma-ray Detection using a Cs_2LiYCl_6 Scintillator

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A new scintillator, Cs_2LiYCl_6 (CLYC), has recently gained interest due to its dual detection capabilities for neutrons and gamma-rays. This sensor can serve in detecting both thermal and fast neutrons from the reactions ^{6}Li(n,α) and ^{35}Cl(n,p), respectively. In addition, this sensor can be used for gamma detection. The current sensor technology that is used to detect fast neutrons and the conventional methods that are applied to derive the energy spectrum have many challenges and drawbacks, such as detection efficiency and energy dependence. CLYC, in this regard, can overcome those challenges. The neutron absorption reaction of ^{35}Cl for high energy neutrons makes this sensor promising by using a distinct proton peak that is proportional to the energy of the incident neutron. Therefore, CLYC has the potential to be used for fast neutron spectrometry and consequently, for neutron dosimetry. The response functions of this detector to neutron and gamma radiation has been obtained using Monte Carlo N-Particle eXtended code (MCNPX). The simulation results and the sensor's applicability to neutron spectrometry and dosimetry has been discussed and analyzed.

International Nuclear Physics Conference INPC2013: 2-7 June 2013, Firenze, Italy

RAON neutron science facility design for measuring neutron-induced cross-section

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In order to produce variety of stable and rare isotopes for basic science, an accelerator complex called RAON is currently under technical design at IBS (Institute for Basic Science), Daejeon, South Korea. The first beam is expected in early 2017. The neutron science facility is a part of RAON to produce white neutron beams covering the 1-50 MeV energy range with a high-intensity as well as a quasi-mono-energetic neutron source. 53 MeV deuterons and 88 MeV protons accelerated by superconducting linac (or 70 MeV protons from cyclotron) are delivered to the neutron production target to produce high energy neutrons, up to more than $\sim 20\mu A$ pulsed beam intense enough for measurements of neutron-induced cross-sections at the neutron time-of-flight (n-TOF) facility [1]. Thick targets such as Be and C are used to produce white neutrons, while thin target such as Li is used to produce quasi-mono energetic neutrons. There are two neutron beam lines at 0° and 30°. Several measurements such as neutron fission (n,f) and capture (n,γ) cross-section are performed coincidently at two points by using n-TOF system with plastic (or liquid) scintillators, HPGe and C_6D_6 detectors. 4 C_6D_6 detectors are used to increase the efficiency of detecting gamma-ray for the accurate measurement of neutron capture cross-section [2]. In order to improve the accuracy of fission cross-section less than 1%, the time projection counter (TPC) will be employed for n-TOF detector system [3].

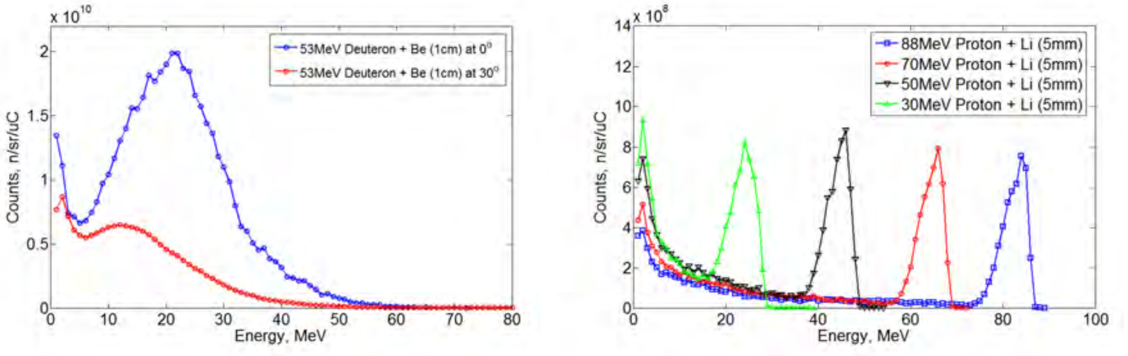

Figure 1: *The white neutron spectra (left) to the direction of* 0° *and* 30° *by 53 MeV deuteron beams with Be target (1cm) and quasi-mono-energetic neutron spectra (right) produced by 88, 70, 50, 30 MeV proton beams with Li target (5mm), which are simulated by MCNPX 2.6 version.*

[1] X. Ledoux et al., Report on the detection and acquisition systems at NFS, HAL-in2p3-00711773, version 1 (2012).
[2] A. Borella et al., The use of C_6D_6 detectors for neutron induced capture cross-section measurements in the resonance region, Nuclear Instruments and Methods in Physics Research A 577, pp. 626-640, (2007).
[3] M. B. Chadwick, Future challenges for nuclear data research in fission, Journal of the Korean Physical Society, Vol 59, No. 2, pp. 752∼754, August (2011).

International Nuclear Physics Conference INPC2013: 2-7 June 2013, Firenze, Italy

Facility for Heavy Ion Collision Experiment at RAON

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The Rare Isotope Science Project (RISP) was established in December 2011 in order to carry out the technical design and the establishment of the accelerator complex (RAON) for the rare isotope science in Korea. The rare isotope accelerator at RAON will provide both stable and rare isotope heavy-ion beams with the energy ranges from a few MeV/nucleon to a few hundreds of MeV/nucleon for the researches in fields of basic and applied science.

Large Acceptance Multipurpose Spectrometer (LAMPS) at RAON is a heavy-ion collision experimental facility for studying nuclear symmetry energy by using rare isotope beams. Two different experimental setups of LAMPS are designed for covering entire energy range at RAON.

One is for a low energy (< 18.5 MeV/nucleon) heavy-ion collision experiment for day-1 experiments. This experimental setup is consisted of cluster array using △E-E technique with Si+CsI detectors, NaI gamma array to cover backward polar angle, and forward neutron wall.

The other is for completing an event reconstruction by detecting the all particles produced from high energy heavy-ion collisions within large acceptance detector to measure particle spectrum, yield, ratio and collective flow of pions, protons, neutrons, and intermediate fragments at the same time. The experimental setup is consisted of superconducting spectrometer, dipole spectrometer, and forward neutron wall. Time Projection Chamber (TPC) will be placed inside of superconducting solenoid magnet of 0.6 T for charged particle tracking device. The dipole spectrometer will be located at forward superconducting spectrometer and it will be composed with the combination of quadruple, dipole magnets, focal plane detector, tracking stations, and Time-of-Flight (ToF) detector at the end. The neutron wall will be made of 10 layers of plastic scintillators for neutron tracking.

In this presentation, the detail physics and design of LAMPS at RAON will be discussed.

International Nuclear Physics Conference INPC2013: 2-7 June 2013, Firenze, Italy

Technical design studies of Large Acceptance Multipurpose Spectrometer (LAMPS) at RAON

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In this presentation, I will show results of simulation studies for Large Acceptance Multipurpose Spectrometer (LAMPS)at RAON. LAMPS is Heavy Ion Collision experiment for studying symmetry energy by using both stable and rare isotope heavy ion beams from RAON accelerator. LAMPS is consisted of two detector setup for low and high energy studies. Gamma detector, Si-CsI and neutron detector is for the low energy ($<$ 18.5 MeV/nucleon) heavy-ion collision experiment. The experimental setup for high energy ($>$ 18.5 MeV/nucleon) is consisted of Time Projection Chamber, Si-CsI detector, neutron wall detector, focal plane detector, Time-Of-Flight and magnet. In order to understand of the each spectrometers and its performance will be crucial to extract the desired physics results from the real data. Simulation studies are needed to optimize and make a decision over the full spectrometer design. Simulation packages like GEANT4 allow to model the each detector geometry and simulate the energy deposit in the different environments. The determination of this detector response is the task of detailed simulation studies, which have to be carried out for each sub-detector. The detail results of simulation studies will be discussed.

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The status of new fragment separator ACCULINNA-2 project and the first day experiments

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The new facility fragment separator ACCULINNA-2 [1] will be put into operation at the beginning of 2015 in FLNR JINR. The new separator is destined to add considerably to the studies of dripline nuclei performed with the use of variety of direct reactions known to be distinctive to the 15 – 50 MeV/amu exotic secondary RIBs. Intense beams provided by the U400M cyclotron will ensure the achievement of this objective. In addition to the RIB separation accomplished by means of the dipole-wedge-dipole selection, the use of RF-kicker technique is planned. A long (13 m) straight section will provide precise time-of-light measurements.

Various kinds of instruments are being developed and/or are already applied in the current experiments performed at the RIBs of the working ACCULINNA separator. Beside a complete set of charged particle detector array, these tools include an array of 32 stilbene scintillator detector of neutrons, cryogenic targets for gas/liquid/solid hydrogen/deuterium and gaseous helium, and unique gas/liquid tritium targets, Optical Time Projection Chamber is used as an active target.

New results obtained in continuation of a recent ^{10}He study [2] show the potential of the (t,p) and (d,p) type reactions for precise study of heavier nuclei nearby the neutron drip line. The excitation spectra of $^{11-13}$Li, $^{13-16}$Be, $^{16-19}$B, and $^{19-22}$C will be a first-priority task for ACCULINNA-2. The search for the few-neutron radioactive decays is a challenging task requiring also application of novel experimental approaches. Quite high intensities of the ^{24}O, ^{26,27}F, $^{28-30}$Ne RIBs offered by ACCULINNA-2 will provide excellent conditions for the study of resonant states of respective nuclei (e.g. $^{24-26}$O) lying near and beyond the drip-line.

ACCULINNA-2 RIBs will offer especially favorable conditions for the study of nuclei beyond the proton dripline carried out with the use of the (p,d), (p,t) and (^{3}He,n) reactions. Recently, the ACCULINNA group performed a dedicated search for the drip-line nucleus ^{26}S produced in fragmentation of a 50.3 MeV/amu ^{32}S beam [3]. An upper half-life limit of $T_{1/2} < 79$ ns was set for ^{26}S in this study. No dedicated search has been performed for the neighbor nuclei ^{21}Mg, ^{30}Ar, and ^{34}Ca yet, which could exist with half-lives shorter than 100 ps. The properties of these nuclei (including also ^{26}S) can be ascertained well with the ACCULINNA-2 RIBs.

[1] Fragment separator ACCULINNA-2. LOI. A.S. Fomichev at all., JINR Communication E13-2008-168, 2010;

[2] Sidorchuk S.I. *et al.,* Phys. Rev. Lett., **108**, 202502 (2012);

[3] A.S. Fomichev et al., Int. Journal of Modern Physics, **20**, 1491 (2011).

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A new neutron detector with a high position resolution for the study of the (p, pn) reaction on rare isotopes

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Nucleon-knockout (p, pN) reactions at intermediate energies provide a powerful probe of the nature of single particle states (SPS's) in nuclei. Exclusive measurements of the (p, pN) reactions allow one to determine the SPS properties, such as occupation probabilities, spectroscopic factors, separation energies, spreading widths, and momentum distributions. Measuring these properties in unstable nuclei is becoming one of hot topics in nuclear experimental physics with the advent of rare-isotope (RI) beam facilities in the worldwide.

In this study, we have developed a prototype neutron detector with a high position resolution better than 3 mm to measure neutrons with kinetic energies ranging from 50 to 200 MeV, emitted from the (p, pn) reactions at 200–300 MeV, which will enable one to measure neutron SPS spectra with an energy resolution of 500 keV. Figure 1 shows a schematic view of the prototype detector, which has a total volume of $30.0 \times 30.0 \times 1000$ mm^3 of a highly-segmented array consisting of 64 plastic scintillating fibers each with a size of $3.75 \times 3.75 \times 1000$ mm^3. Scintillation photons generated in each fiber are read out using the multi-anode PMT (Hamamatsu H7546B), where photo-electron signals are independently multiamplified for each anode channel without losing the information on the fiber position where the photon is generated.

In November 2012, a test experiment of the prototype detector was performed at the Cyclotron and Radioisotope Center (CYRIC), Tohoku University for examining the method to reconstruct the neutron hit position as well as to calibrate the detection efficiency.

A preliminary analysis shows the detection efficiency is about 2.0% and 1.6% for 68- and 50-MeV neutrons, respectively, when setting the threshold to the dynode signal of each PMT around 4 MeV electron-equivalent energy. Figure 2 shows a hit pattern of anodes of the PMT in the unit of QDC channels for a typical event where an incident neutron is detected by scatting a proton in the scintillation material. Using this hit pattern information, the detection of the incident neutron can be clearly identified, implying that the position uncertainty of ± 1.75 mm can be achieved by this method. The detailed analysis for establishing the method of the hit-position reconstruction is under progress.

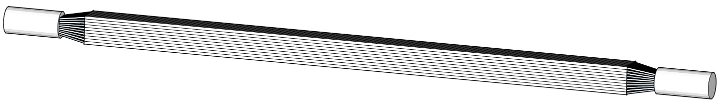

Figure 1: *A schematic view of the prototype detector. It consists of 64 plastic scintillating fibers each with a size of* $3.75 \times 3.75 \times 1000$ *mm*^{3}. *Scintillation photons are read out using the multi-anode PMT and pitch converter using normal optical fibers with a diameter of 2 mm.*

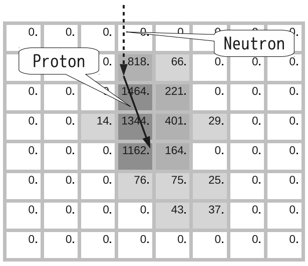

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Figure 2: *An example of the hit pattern.* 8×8 *numbers indicate the light output in the each segment.*

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Perspectives and upgrade of ALICE at the LHC

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ALICE, collecting data from Pb-Pb, p-Pb and pp collisions at the LHC, is devoted to the characterization of strongly interacting matter at unprecedented energy densities. The first running period, which will extend until 2017, has already brought outstanding results. It can provide a description of the global bulk phenomena and a first set of exciting insights into rare probes but will leave many important questions unanswered. Only the exploitation of the high luminosity in Pb-Pb collisions foreseen after 2018, together with the recent technological advances, will allow one to adress new scientific challenges and enable detailed studies of hot QCD matter properties thanks to rare processes otherwise unreachable. ALICE is therefore setting up a program of detector upgrades targeting physics topics related to open heavy flavors, quarkonia, low-mass dileptons, jets and the search for exotica. An overview of the physics motivations as well as a description of the technological challenges and choices for the detector upgrades will be presented.

International Nuclear Physics Conference INPC2013: 2-7 June 2013, Firenze, Italy

Design of KOBRA (Korea Broad acceptance Recoil Spectrometer and Apparatus) at RAON accelerator complex

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The Rare Isotope Science Project (RISP) was established in December 2011 in order to carry out the technical design and the construction of the RAON accelerator complex for the rare isotope science in Korea. The ultimate goal of the RAON is to produce variety of a stable and rare isotope beams to be used for researches in fields of basic and applied science. The various experimental systems are being designed for measurements with stopped (~ 5 keV/nucleon), low energy (< 18.5 MeV/nucleon) and high energy (up to few hundreds MeV/nucleon) heavy ion beams.

KOBRA (Korea Broad Acceptance Recoil Spectrometer and Apparatus) is being designed for studying nuclear spectroscopy, nuclear astrophysics, symmetry energy and spin polarization with high intensity stable and rare isotope beams up to 18.5 MeV/nucleon from ISOL system and superconducting post linear accelerator of RAON. KOBRA consists of in-flight separator (CRIB [1]-like, double achromatic separator + Wien filter) and rotatable large acceptance spectrometer (VAMOS [2]-like, Q-Q-WF-D) with the large effective solid angle of ~ 20 to 50 msr. The status of technical design for electromagnetic system and associate equipments will be presented.

[1] Y. Yanagisawa et al., Nucl. Instr. and Meth. A 539, 74 (2005);
[2] Herve Savajols et al., Nucl. Instr. and Meth. B 204, 146 (2003).

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AFTER@ LHC: A Fixed-Target ExpeRiment at the LHC

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We outline the physics opportunities [1] which are offered by a next generation and multi-purpose fixed-target experiment exploiting the LHC beams extracted by a bent crystal. This mature extraction technique offers an ideal way to obtain a clean and very collimated high-energy beam, without altering at all the performance of the LHC [2, 3, 4]. The multi-TeV LHC beams grant the most energetic fixed-target experiment ever performed, to study pp, pd and pA collisions at $\sqrt{s_{NN}} \simeq 115\,\mathrm{GeV}$ and PbA collisions at $\sqrt{s_{NN}} \simeq 72\,\mathrm{GeV}$. AFTER – for A Fixed-Target ExperRiment – gives access to new domains of particle and nuclear physics complementing that of collider experiments, in particular RHIC and the projects of electron-ion colliders. The typical instantaneous luminosity achievable with AFTER in pp and pA mode [1] surpasses that of RHIC by more than 3 orders of magnitude and is comparable to that of the LHC collider mode. This provides a quarkonium and heavy-flavour observatory [5] in pp and pA collisions where, by instrumenting the target-rapidity region, gluon and heavy-quark distributions of the proton, the neutron and the nuclei can be accessed at large x and even at x larger than unity in the nuclear case. The nuclear target-species versatility provides a unique opportunity to study nuclear matter versus the features of the hot and dense matter formed in heavy-ion collisions, including the formation of the quark-gluon plasma. During the one-month lead runs, PbA collisions can be studied at a luminosity comparable to that of RHIC and the LHC over the full range of target-rapidity domain with a large variety of nuclei. Modern detection technology should allow for the study of quarkonium excited states, in particular the χ_c and χ_b resonances, even in the challenging high-multiplicity environment of pA and PbA collisions, thanks to the boost of the fixed-target mode. Precise data from pp, pA and PbA should help to understand better heavy-quark and quarkonium production, to clear the way to use them for gluon and heavy-quark PDF extraction in free and bound nucleons, to unravel cold from hot nuclear effects and to restore the status of heavy quarkonia as a golden test of lattice QCD in terms of dissociation temperature predictions at a $\sqrt{s_{NN}}$ where the recombination process is expected to have a small impact. The fixed-target mode also has the advantage to allow for spin measurements with polarized targets.

[1] S. J. Brodsky, F. Fleuret, C. Hadjidakis and J. P. Lansberg, Phys. Rept. **108** 522 (2013) 239.
[2] E. Uggerhøj, U. I. Uggerhøj, Nucl. Instrum. Meth. B **234** (2005) 31.
[3] W. Scandale, *et al.*, Phys. Lett. B **703** (2011) 547-551.
[4] W. Scandale, *et al.* [LUA9], CERN-LHCC-2011-007, 2011.
[5] J. P. Lansberg, S. J. Brodsky, F. Fleuret and C. Hadjidakis, Few Body Syst. **53** (2012) 11

Charged particle identification using pulse shape in FAZIA silicon detectors

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The response of silicon-silicon-CsI(Tl) telescopes, developed within the FAZIA collaboration [1], to fragments produced in nuclear reactions, has been used to study ion identification methods [2, 3]. Different techniques have been considered for the identification of the nuclear products in the silicon stages. The standard ΔE-E one requires signals induced in two detection layers by ions punching through the first one. Conversely, the digital Pulse Shape Analysis (PSA) allows the identification of ions stopped in the first silicon layer. Several techniques [4, 5] have been investigated using either charge or current signals coming from a dedicated pre-amplifier [6]. Those techniques have been compared in terms of identification quality, resolution and thresholds for detection capabilities [7]. These methods have been also tested for different mountings of the silicons, i.e. rear (particles entering through the low electric field side) or front (particles entering through the high electric field side) side injection [8]. The ΔE-E identification method gives exactly the same results in both configurations. At variance, the pulse shape discrimination is very sensitive to the detector mounting. In case of rear side injection, the identification with the "energy vs charge rise time" PSA method presents energy thresholds which are significantly lower than in the case of front side injection. Dedicated analyses have also been performed to check the reliability of the previous methods under radiation damage [9]. Sizeable effects on the amplitude and the rise time of the charge signal have been found for detectors irradiated with large fluences of stopped heavy ions, while much weaker effects were observed by punching-through ions. The robustness of ion identification based on digital pulse shape techniques has been evaluated.

[1] Web site Fazia collaboration (http://fazia.in2p3.fr/spip2/)
[2] L. Bardelli et al., NIMA 602 (2009) 501
[3] L. Bardelli et al., NIMA 605 (2009) 353
[4] S. Barlini et al., NIMA 600 (2009) 644
[5] L. Bardelli et al., NIMA 654 (2011) 272
[6] H. Hamrita et al., NIMA 531 (2004) 607
[7] S.Carboni et al., NIMA 664 (2012) 251
[8] N. Le Neindre et al., NIMA 701 (2013) 145
[9] S. Barlini et al., NIMA (2013) in press (http://dx.doi.org.10.1016/j.nima.2012.12.104)

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Beam Line Design of DIAC as a Stable Heavy-Ion Accelerator at KAERI

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TRIAC(Tokai Radioactive Ion Accelerator Complex) was a radioactive isotope accelerator that can provide beams of uranium fission fragments with the maximum energy of 1.1 MeV/u. Due to the critical limitations in the reaccelerated energy and intensity of available radioactive ion beams, TRIAC considered an upgrade program seriously, but it was canceled[1]. Finally the complex had been been closed at the end of 2010, and it was transferred to KAERI(Korea Atomic Energy Research Institute) after being disassembled to promote a new availability in Korea. KAERI team named this device as DIAC(Daejeon Ion Accelerator Complex). The beam optics of the DIAC components was calculated by TRANSPORT simulation code[3]. The calculation of the program is based on the transfer matrix method of the accelerators components. Many parameters such as mass number, charge, energy, emittance and rigidity for the beam optical calculations are required. The beam parameters of the ECR ion source and the charge breeder used at TRIAC are prepared by referring the experimental data[1,2]. The transfer matrices of the accelerator components such as SCRFQ, re-buncher and IH-linac are simplified by using the old TRIAC data. The operation conditions and beam optics characteristics of the new beam line components can be understood with this simulation. Figure 1 shows a schematic of the planned newly reassembled the DIAC at KAERI. Stable ions for the accelerator will be produced by 14.5 GHz ECR ion source which was developed at KAERI[2] and 18 GHz charge breeder, which was used at TRIAC ISOL system. The ion source will be used in producing multi-charge gas ions, and the charge breeder will be used in producing multi-charged metal ions. The emittance and charge state of the selected ion beams should be controlled well to match with the first accelerator SCRFQ acceptance. The SCRFQ linac, which has a 25.96 MHz frequency, accelerates the matched beams up to 178.4 keV/u. This beam is transferred to IH-linac, which has a 51.92 MHz frequency, and is finally accelerated up to 1.1 MeV/u. Multiple purpose target and detection system will be developed with 2 large analyzing magnets to execute basic physics and beam application studies.

The reassembly of the DIAC system at KAERI was started from August of 2012, and it is expected that 3 years will be taken to finish assembling and tuning of the system. The DIAC will be used not only for the basic research but also for the application of heavy ion beams.

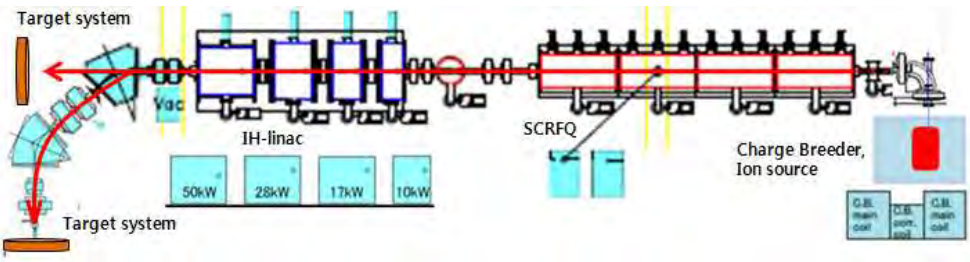

Figure 1 : Schematic of the DIAC with target system applied to ECR ion source and Charge breeder

[1] S. C. Jeong, et al., TRIAC Progress Report, KEK, (2011)
[2] Byung-Hoon Oh, et al., Journal of the Korean Physical Society, 58(4), 771-775, (2011)
[3] PSI Graphic Transport Framework by U. Rohrer based on a CERN-SLAC-FERMILAB version by K.L. Brown et al.

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GRETINA results from physics campaign at NSCL

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The gamma ray energy tracking array GRETINA was completed in March 2011. Extensive tests were carried out using radioactive sources and beams from the 88-Inch Cyclotron at LBNL. Its first physics campaign started April 2012 at the National Superconducting Cyclotron Laboratory (NSCL). More than 20 experiments were scheduled to be completed before July of 2013. These experiments cover studies of nuclear structure in neutron-rich and proton-rich region, nuclear reaction, and nuclear astrophysics. GRETINA was installed centered at the target of the S800 spectrograph with of 28 36-fold segmented Ge detector, covering 1-π solid angle. The tracking detectors have the unique ability of resolving the energy and position of the individual interaction points and establishing the gamma-ray scattering sequence. GRETINA with S800 is a powerful combination for fast radioactive beam experiments at NSCL; their high position resolution is crucial for Doppler correction to achieve good energy resolution; their higher efficiency overcomes the low intensity of exotic beams and extends the range of study to more neutron-rich and proton-rich nuclei; and gamma ray tracking reduces background and improves spectral quality. We will report on selected results from the campaign of GRETINA at the S800 and discuss the future plans.

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A Detector for Electron-Ion Scattering Experiments at the LHeC

The LHeC Study Group

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Based on the recently published Conceptual Design Report for the LHeC electron-hadron collider at the LHC, this presentation covers the main concepts and challanges of building a new detector, which will be required to make high precision and large acceptance measurements in deep inelastic electron-proton and electron-ion scattering. The detector uses modern technology for the tracking and calorimetry, based on a central detector in a 3.5 T solenoid field. It includes small angle backwards acceptance to measure the lowest momentum transfers Q^2 and forwards acceptance to cover large Bjorken x. The talk also covers the status of the detector development and the prospects for its realisation.

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The LHeC - A High Energy Electron-Ion Collider

The LHeC Study Group

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Recently the Conceptual Design Report was published for the LHeC, which is the project to build a 60 GeV electron beam tangential to the LHC. It will produce unprecedented high energy deep inelastic electron-proton and electron-ion scattering as part of the LHC operation in the 2020s. With its unique electron-ion physics programme, the LHeC has been included in the long range plan of NuPECC as part of the future of European nuclear physics. This talk presents the solutions considered for the electron beam as an energy recovery linac, its layout as an eA collider, and discusses the status and prospects of the LHeC project overall.

International Nuclear Physics Conference INPC2013: 2-7 June 2013, Firenze, Italy

KRATTA, a versatile triple telescope array for charged reaction products

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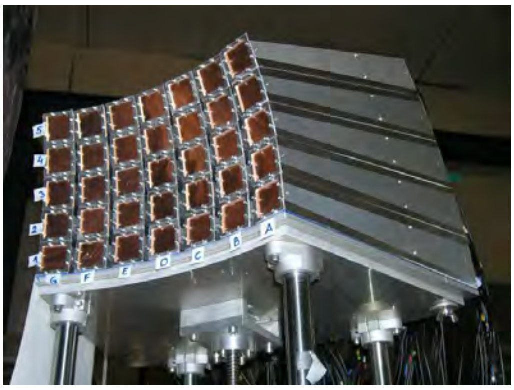
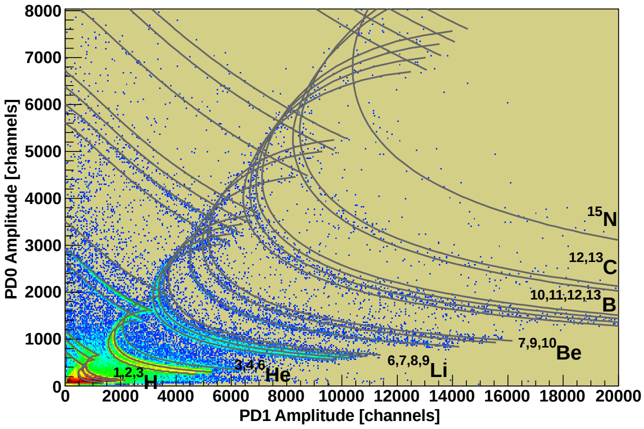
A new detection system KRATTA, Krakow Triple Telescope Array, will be presented. This versatile, low threshold, broad energy range system has been built to measure the energy, emission angle, and isotopic composition of light charged reaction products. It consists of 38 independent modules which can be arranged in an arbitrary configuration. A single module, covering actively about 4.5 msr of the solid angle at the optimal distance of 40 cm from the target, consists of three identical, 500 μm thick, large area photodiodes, used also for direct detection, and of two CsI(1500 ppm Tl) crystals of 2.5 and 12.5 cm length, respectively. All the signals have been digitally processed. The lower identification threshold, due to the thickness of the first photodiode, has been reduced to about 2.5 MeV for protons (~65 μm of Si equivalent) by applying a pulse shape analysis. The pulse shape analysis allowed also to decompose the complex signals from the middle photodiode into their ionization and scintillation components and to obtain a satisfactory isotopic resolution with a single readout channel. In addition, it allowed to obtain the ballistic deficit free amplitudes, suitable for energy calibration and identification based on predictions of the range-energy tables, and last but not least, it allowed to isolate and reduce the substantial amount of background resulting from the secondary reactions in the crystals. The upper energy limit of the array amounts to about 260 MeV for protons. The whole setup is easily portable. It performed very well during the ASY-EOS experiment, conducted in May 2011 at GSI. The structure and performance of the array will be presented with the emphasis on the advantages of the digital signal processing and the pulse shape analysis.



KRATTA in a 7×5 configuration.



ΔE-E map with the calculated ID lines.

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Status of the RFQ Beam Cooler for SPES project at LNL

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The SPES project is the new Radioactive Ion Beam facility under construction at Laboratori Nazionali of Legnaro, Italy. In this framework, the realization of a new RFQ Beam Cooler (RFQBC) is in progress (fig. 1). This device allows to improve the quality of the low energy ion beams produced by the ISOL technique, in terms of reduced transverse emittance and low energy spread. The RFQBC is an electromagnetic apparatus operating with oscillating electric fields needed to confine the very low energy (eV) ions (Q=1+) which lose both the longitudinal and transversal momentum by making collisions with lighter atoms of so called buffer gas (He). This process provides the reduction of the transversal emittance up to 10 times of the initial value and it keeps the energy dispersion within 2-3 eV.

The electromagnetic design of the RFQ section and the electrostatic layout of the injection and extraction regions have been done. The beam dynamics study is going on by means of dedicated codes which allow to take into account the interaction of the ions with the buffer gas needed to cool the beams. The RF group of LNS Catania is involved in the design of the RF system (500W) providing the oscillating high voltage (up to 3 kV) at frequency which varies in the range of 1-30 MHz. The preliminary design of the device started in 2011 by V committee of INFN in the framework of REGATA experiment and it is carrying on within the COOLBEAM experiment. Both beam dynamics study and the electromagnetic design are presented in this work together with the experimental set up to investigate the sustainability of high voltages at low He pressure. After the preliminary evaluation and the phase study [1] [2] the Beam Cooler is being constructed and his completion is expected in 2014.

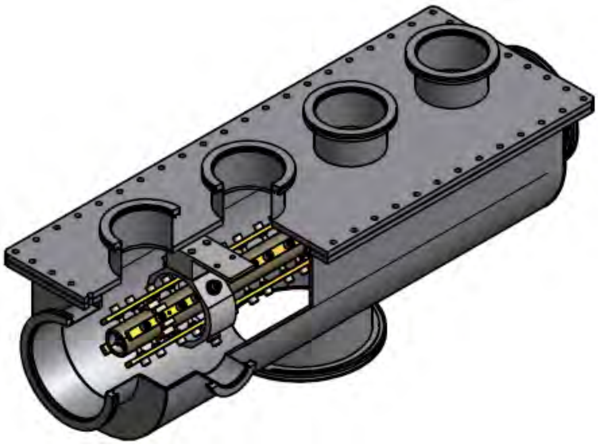

Figure 1: *Technical drawing of the RFQ device placed in the vacuum chamber*.

[1] M.Maggiore et al., proceedings of IPAC 2012, New Orleans, USA, 2012.
[2] M.Maggiore et al., proceedings of HIAT 2012, Chicago, USA, 2012.

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Recent developments at the ISOL SPES facility

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The SPES project at Laboratori Nazionali di Legnaro (INFN, Italy) is mainly focused on the production of neutron-rich radioactive nuclei by the uranium fission at a rate of 10^{13} fission/s [1]. The emphasis to neutron-rich isotopes is justified by the fact that this vast territory has been little explored, with the exception of some decay and in-beam spectroscopy following fission. The Radioactive Ion Beam (RIB) will be produced according to the ISOL technique, making use of proton induced fissions on a UCx direct target. The core of the SPES facility is constituted by the "target – ion source" system, that converts a 40 MeV 200μA proton beam (primary beam) in a radioactive ion beam (secondary beam). The Multi-Foil Direct Target represents an innovation in terms of capability to sustain the primary beam power. The design is carefully oriented to optimise the cooling by thermal radiation, taking advantage of the high operating temperature of 2000°C. In this work the recent developments on fabrication, characterization, and testing of the SPES target will be presented. Developments on ion-sources [2], in particular their recent off-line characterization, will be also discussed.

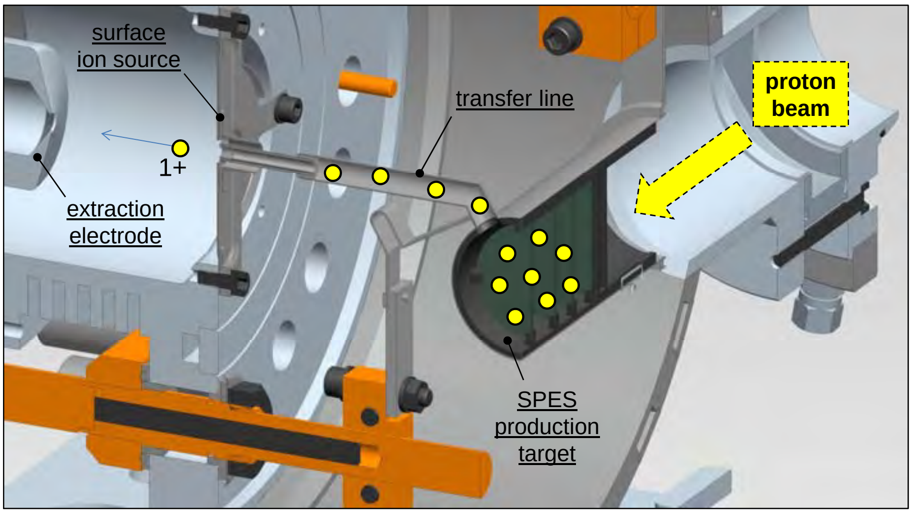

Figure 1: *The SPES "target – ion source" system.*

[1] A. Andrighetto, C.M. Antonucci, S. Cevolani, C. Petrovich, M. Santana Leitner, Multifoil UCx target for the SPES project – An update, Eur. Phys. J. A 30 (2006) 591-601;
[2] M. Manzolaro, G. Meneghetti, A. Andrighetto, Thermal–electric numerical simulation of a surface ion source for the production of radioactive ion beams, Nucl. Instrum. Methods Phys. Res., Sect. A 623 (2010) 1061-1069.

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A New Digital Electronics Set-up for Nuclear Physics Experiments

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A new Digital Electronics set-up for Nuclear Physics Experiments has been developed at LNL in view of the future experimental campaign with the exotic beams that will be delivered by SPES [1].

The hardware consists of commercial CAEN VME digitizers with different sampling rates (100, 250, 1000 MS/s) and resolutions (14, 12, 10 bits). These devices are used to acquire the output signals of several type of detectors such as liquid or plastic scintillators for neutron detection, inorganic scintillators for high energy gamma-rays detection, solid state silicon detectors for charged particle measurement or HPGe for gamma-ray spectroscopy. The system easily allows for the acquisition of several tens of channels. The firmware used by these digitizer modules has been extended in order to propagate in daisy chain the clock between different boards and obtain their synchronization. A trigger module [2] implemented and used in experiments with the GARFIELD array [3] has been integrated in the system, allowing for multiple trigger channels built with flexible logic, down-scaling, trigger pattern recording and accurate live-time throttling and measurement. Input waveforms, continuously stored in the digitizers' circular buffers, are readout upon any active trigger channel assertion and are transferred via optical links at 640Mb/s to a PC running a Linux OS (not optimized for real-time operation). A fully custom DAQ code is used for collecting and synchronizing data from all the digitizers and the other VME modules. Before storage on disk, the DAQ allows performing fast data on-line selection, zero-suppression and compression.

A dedicated analysis software, based on the ROOT package [4], has been developed. This tool performs the pulse shape processing of the raw data, the events reconstruction and provides a graphical user interface for on-line monitoring purposes. Particular attention has been given to the development and optimization of the algorithms for pulse shape analysis (e.g. n/γ discrimination in standard liquid and in new polisyloxane [5] scintillators) and time measurement needed in neutron spectroscopy experiments and/or used for a complete kinematics reconstruction of binary reactions.

The performances of the new set-up achieved in two different in-beam experiments will be discussed together with the improvements foreseen in the next future.

[1] http://spes.lnl.infn.it/
[2] G. Pasquali et al., to be published
[3] F. Gramegna et al., Nucl. Inst. Meth. A 389, 474 (1997)
[4] http://root.cern.ch
[5] S. Carturan et al., Radiation Protection Dosimetry 143, 471 (2011

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TRACE: a charge-particle detector for the the new RIB facilities

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Various physics themes have been addressed, during the AGATA Demonstrator experimental campaign at LNL, by exploring different mass regions in the nuclear landscape, ranging from the study of the hydrogen burning CNO cycle in the light ^{15}O nucleus to the non-yrast octupole-deformed bands expected in the moderately p-rich ^{222}Th,^{220}Ra heavy nuclei. In this campaign, detectors complementary to AGATA had a prominent role, making possible, by increasing the sensitivity of the gamma-tracking spectrometer, the study of the exotic proton- and neutron-rich nuclei away from the valley of beta stability. In particular the light-charged-particle detector TRACE [1] has been used in the study of the origin of cluster-bands in ^{21}Ne and of high-collective dipole and quadruple modes in ^{208}Pb and ^{90}Zr.

The present contribution focuses on the results and the performance achieved during the successful AGATA campaign at LNL, and will report on the status of the highly segmented silicon array TRACE in the framework of the European partner projects, such as GASPARD (SPIRAL2) and HYDE (FAIR), and in view of the construction of the radioactive beam facility SPES at LNL (Italy). Recent results obtained on the digital pulse shape analysis [2] will be also part of the discussion.

[1] A. Gadea et al., NIM A 654 (2011) 8896.
[2] J.Dueñas et al., NIM A 676 (2012) 7073.

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ARIEL: TRIUMF's Advanced Rare IsotopE Laboratory

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TRIUMF, Canada's national laboratory for Nuclear and Particle Physics, has recently embarked on the construction of ARIEL, the Advanced Rare IsotopE Laboratory, with the goal to ultimately triple the current Rare Isotope Beam capability. ARIEL will use proton-induced spallation and electron-driven photo-fission of ISOL targets for the production of short-lived rare isotopes that are delivered to experiments at the existing ISAC facility. I will present an overview of the ARIEL project and status of design and construction of the new high power superconducting electron linear accelerator, and give a status report on the VECC-TRIUMF Test Facility that serves as a system integration test of the ARIEL electron linac.

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A Novel Spin-Light Polarimeter for the Electron Ion Collider [1]

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High precision polarimetry is a pre-requisite for the suite of precision experiments being planned for the proposed Electron Ion Collider. A novel polarimeter based on the asymmetry in the spacial distribution of the spin light component of synchrotron radiation will make for a fine addition to the existing-conventional Møller and Compton polarimeters [a]. The spin light polarimeter consists of a set of wiggler magnet along the beam that generate synchrotron radiation. The spacial distribution of synchrotron radiation will be measured by an ionization chamber. The up-down (below and above the wiggle) spacial asymmetry in the transverse plain is used to quantify the polarization of the beam. As a part of the design process, the fringe fields of the wiggler magnet was simulated using a 2-D magnetic field simulation toolkit called Poisson Superfish, which is maintained by Los Alamos National Laboratory. The effects of the fringe field was found to be negligible [b]. Lastly, a full fledged GEANT-4 simulation was built to study the response of the ionization chamber. The results from all the simulations carried out, the preliminary design parameters of the polarimeter and its impact will be discussed.

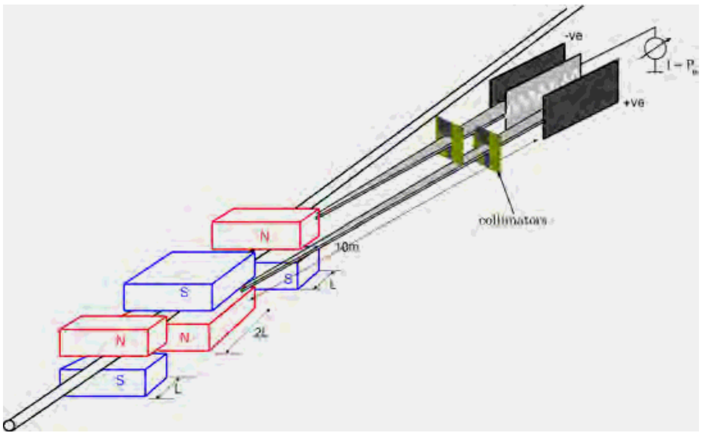

Figure 1: *Schematic layout of the Spin-Light Polarimeter apparatus*

[a] D. Dutta, Feasibility of a spin-light polarimeter at JLab; J. Phys. Conf. Ser. 295 (2011) pp 012141.
[b] D. Dutta et. al., Development of a Spin-Light Polarimeter for the EIC; Proposals to Brookhaven National Laboratory EIC R & D Grants, https://wiki.bnl.gov/conferences/images/7/74/RD2012-11_Dutta_eic_polarimetry.pdf (2012).

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[1] This work is supported by the JSA - Jefferson National Accelerator Facility

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A unique TAS setup for high multiplicity events at VECC, Kolkata using BaF_2 detectors

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The Total Absorption spectroscopy measurements have become a very important field of experimental nuclear physics research as it has application in both basic and applied sciences [1]. In TAS setup, one measures the sum energy of the γ rays, e.g from the beta decay and deduces the feeding intensities which are free from the, so called, pandemonium effect. Most of the TAS setups, currently in use, are based on large volume NaI (Tl) or BaF_2 detectors which have high efficiency for γ ray detection. One of the deficiencies of such large volume setups is that it cannot distinguish a large energy single γ-ray from the cascade of γ-rays whose sum is close to that of a single γ-ray energy. At VECC a TAS setup has been developed using closely packed 50 numbers of smaller volume BaF_2 detectors which can be used to overcome the above deficiency using multiplicity gated sum energy without compromising on the detection efficiency. The details about the detectors can be found in Ref.[2]. The setup is consisted of two halves with 25 detectors in each arranged in a castle type geometry. The two halves are shown in Figure 1. The source may be placed in the middle before closing the halves. The setup has been tested using different radioactive sources which has different numbers of cascading γ rays. Sum spectra are obtained in the offline analysis with different conditions of multiplicity and the effect of higher multiplicity on the sum spectrum has been tested. The known strong β-feeding intensities of the ^{152}Eu source are well reproduced in the sum spectrum gated by high multiplicity. This VECC TAS setup is a unique setup particularly for the high multiplicity cascade events. The response of the setup has been compared with the GEANT-3 simulation and the setup is ready to be used for the decay measurements. The details of the setup and the test results will be presented.

Figure 1: *The two halves of the TAS array at VECC.*

[1] . Algora et al., Phys. Rev. Lett. 105, 202501 (2010); J. Korean Phys. Soc. 59, 1479s (2011)
[2] Deepak Pandit et al., Nucl. Inst. Meth. Phys. Res. A624, 148 (2010).

First Beam Production and Commissioning Runs at SPring-8 LEPS2

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A new beamline, which produces a Laser Compton Scattering (LCS) photon beam, has been constructed at SPring-8 for the purpose to promote hadron photoproduction experiments, called LEPS2. The LEPS2 beamline is designed to provide photon beam intensities of $\sim 10^7$ sec^{-1} and $\sim 10^6$ sec^{-1} for the LCS beams with the maximum energies of 2.4 GeV and 2.9 GeV, respectively. These intensities are about one order higher than those of the LEPS experiments, which have been operated for 12 years [1]. Thanks to the good divergence of electron beam at the LEPS2 beamline, the LCS beam is well collimated even at the 135 m downstream of scattering point. Therefore, large solid angle detectors with high resolutions are constructed outside the storage ring building as shown in Fig.1.

In the end of January 2013, the first LCS beam is being obtained at the LEPS2 beamline. Observed beam properties will be reported for the first time along with upgrade plans. Simultaneously, a new detector system "BGOegg", which consists of a large acceptance electromagnetic calorimeter, has been installed into the LEPS2 experimental hall. The BGOegg provides the world best energy resolution of 1.3% for 1 GeV. Commissioning runs for the BGOegg experiments are also being conducted with the first LCS beam. Snapshots from the first data and future prospects of the LEPS2 experiments will be discussed with expected physics programs. We plan to study η'-mesic nuclei, highly excited baryon resonances, and so on by the BGOegg experiments [2].

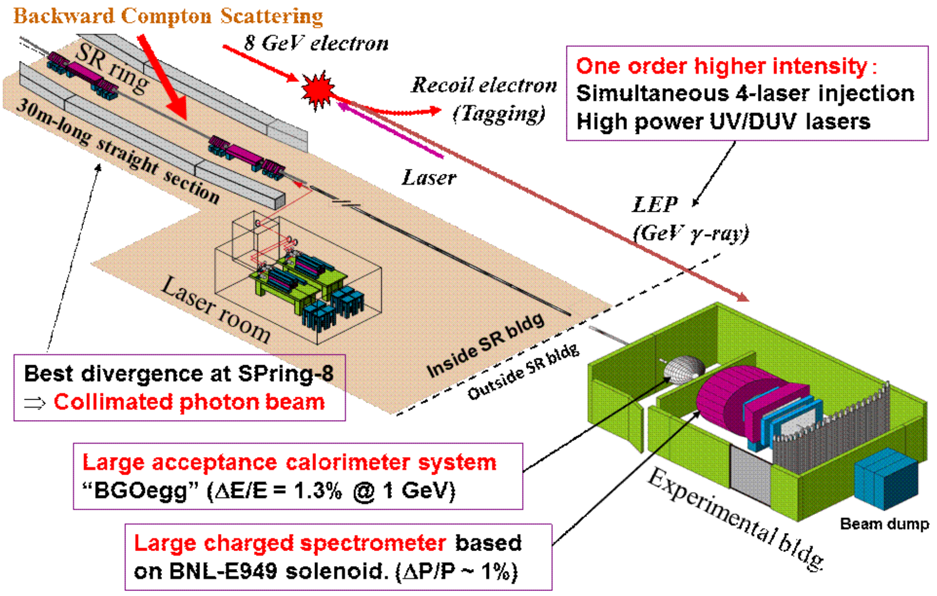

Figure 1: *Schematic view of the LEPS2 facility.*

[1] N. Muramatsu, arXiv:1201.4094 (2012).
[2] Letter of Intent for the BGOegg experiment (2012).

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Beta-delayed neutron spectroscopy with a specialized ion trap and detector array

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Studies of β-delayed neutron emission are needed for the design of Generation IV nuclear reactors [1], an improved understanding of the astrophysical r-process, and to provide important constraints on neutron capture cross sections [2] for stockpile stewardship.

A new radiofrequency-quadrupole ion trap is being constructed to measure β-delayed neutron emission in neutron-rich isotopes. The ions of interest are trapped in a ~1-mm^3 space with RF and DC electric fields and cooled to less than 1 eV using a low pressure helium buffer gas. The β-delayed neutron spectra are acquired from the time of flight of the recoiling ion instead of directly detecting the neutron. This new ion trap design is based upon the current β-decay Paul trap [3] with a more sophisticated detector array. Eight plastic scintillator ΔE-E telescopes will surround the center of the trap to detect the β decay electrons. Four microchannel plate (MCP) detectors will acquire the timing and position of recoiling daughter ions and four high purity germanium (HPGe) clover detectors will detect γ rays. Furthermore, it will have an improved electrode geometry that reduces the perturbation on the recoil ions emerging from the trap. As a result, there will be better separation of the β-decay and delayed-neutron emission ions, which allows for a lower threshold on measuring neutron energy (50-100 keV range).

This new trap will take advantage of the fission fragment beams from the CARIBU (Californium Rare Isotope Breeder Upgrade) facility at Argonne National Laboratory. The intensity of the beams available from the CARIBU source will be several orders of magnitude greater than those used to demonstrate the technique [4]. The new trap and detector array will be capable of measuring decays from neutron-rich beams with intensities as low as 0.1-1 ions per second. With this sensitivity, measurements can be performed for nuclei at or near the r-process path.

This presentation will cover the designs for the new trap and plans for upcoming measurements. This system will provide high-statistics data on the β-delayed neutron emission processes needed for addressing issues in stockpile stewardship and reactor safety and design.

This work was supported by U.S. DOE under Contracts DE-AC52-07NA27344 (LLNL), DE-AC02-06CH11357 (ANL), DE-FG02-98ER41086 (Northwestern U.), NSERC, Canada, under Application No. 216974 and the Department of Homeland Security.

[1] S. Das, Prog. Nucl. Energy **28**, 209 (1994)
[2] K.-L. Kratz et al., Astron. Astrophys. **125**, 381 (1983)
[3] N.D. Scielzo *et al.*, Nucl. Instr. and Meth. A **681**, 94 (2012)
[4] R.M. Yee *et al.*, accepted to be published in Phys. Rev. Lett.

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Ion-optical design of KOBRA at RAON

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The recoil spectrometer KOBRA for studying nuclear physics at RAON accelerator complex in Korea is being designed. KOBRA consists of two stages of in-flight separator ("stage 1") and large acceptance spectrometer ("stage 2"). "Stage 1" can be utilized for the production and separation of RI beams with high intensity stable ion beams (up to 18.5 MeV/nucleon) extracted from linear accelerator of RAON. And also "stage 1" can deliver the stable ion beams to the reaction target at double achromatic focus point which is located in the middle of "stage 1" and "stage 2". "Stage 2" is the large-bite spectrometer for identification of particles from various nuclear reactions. The beam line is about 25 meter length and has four focusing points (two achromatic focuses and two dispersive focuses) and two Wien filters for better separation of RI beams and reaction products. Calculation of ion optics has been performed with GICOSY[1] and K-trace [2,3] codes which are based on matrix and ray-tracing methods, respectively. Structures of optical elements of KOBRA were optimized by comparing with results of the two codes to obtain maximum angular and momentum acceptances at final dispersive focusing point. In this presentation, the results for ion optics calculations and also Monte-Carlo simulation by MOCADI code [4] with the result of third-order optics calculation by GICOSY will be discussed.

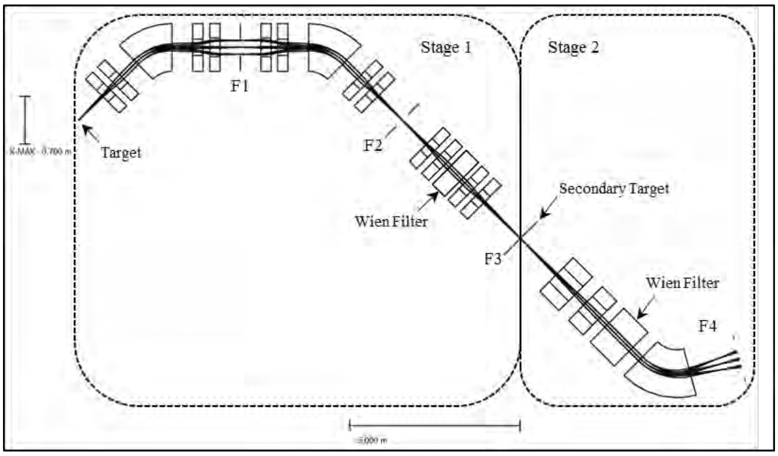

Figure 1: *Schematic view of the KOBRA.*

[1] H.Weick, GICOSY homepage, http://www.linux.gsi.de/~weick/gicosy
[2] S. Kato, Nucl. Instr. and Meth. A 540 (2005) 1.
[3] S. Kato, Nucl. Instr. and Meth. A 611 (2009) 1.
[4] H.Weick, MOCADI homepage, http://web-docs.gsi.de/~weick/mocadi/index.html

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Energy Spread and Emittance Simulation for RISP RFQ Cooler

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We designed and simulated a RFQ cooler [1, 2] to accommodate the need for improving the beam quality from the ISOL target. High resolution mass separator requires smaller emittance and energy spread to achieve its target resolving power. Our goad of the RFQ cooler design is to obtain emittance of less than 3π mm mrad at 20 keV beam energy and energy spread of a few 1 eV. SIMION code is used for the calculation employing hard sphere collision model for the buffer gas cooling process. From the simulation with various operation conditions, we found the importance of the buffer gas pressure inside the injection and extraction region. Vacuum condition along the beam path has crucial impacts on the efficiency, emittance, and energy spread of the output beam. In order to take account of the pressure change near the hole of the differential pumping aperture that located in between RFQ electrode and extraction electrode, we calculated the pressure distribution of that region using Molflow+ code (see Figure 1). The energy spread of DC output beam depends on the potential gradient along the beam axis while that of bunched beam is affected by the depth of potential well and pushing voltage profile in time and space. Figure 2 shows our simulation results of output emittance and energy spread against the location of differential pumping diaphragm. As can be seen from the figure, energy spread is reduced more than a factor of two by moving the diaphragm about 10 mm from the start of extraction optics to the end of RFQ electrode. This means that when ions start to accelerate, buffer gas at that region should be minimized to suppress the energy broadening by the gas collision inside the acceleration region. In this presentation we will talk more about simulation results from various operation conditions including transmission efficiency against buffer gas pressure, test of calculation error of SIMION code, etc.

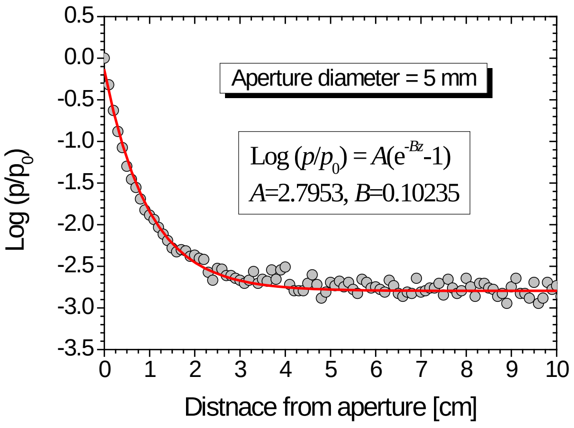

Figure 1: *Calculated pressure distribution along beam axis*

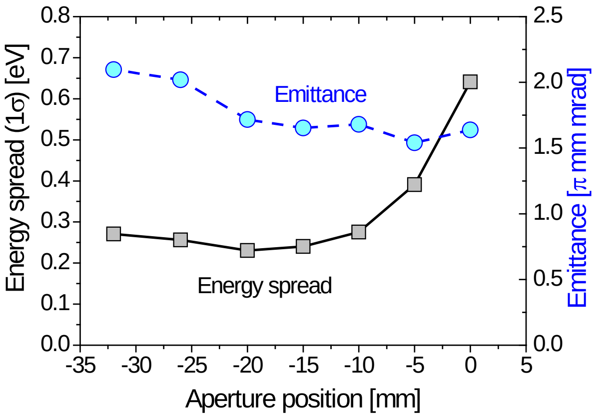

Figure 2: *Characteristics against location of differential pumping diaphragm*

[1] R. B. Moore, O. Gianfrancesco, R. Lumbo, S. Schwarz, “The use of high RFQ fields to manipulate ions,” Int. J. Mass Spectrom. **251** (2-3) 190-197 (2006).

[2] M. Smith, L. Blomeley, P. Delheij, J. Dilling, “First tests of the TITAN digital RFQ beam cooler and buncher,” Hyperfine Interactions **173** (1) 171-180 (2006).

Energy and time characterization of Hamamatsu Photonics silicon photomultipliers

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We have characterized the intrinsic energy and time resolution of Hamamatsu Photonics silicon photomultipliers (SiPM/MPPC) S10362-11-050P and S10362-33-050C, both having a cell size of 50x50 μm^2, sensitive area of 1x1 mm^2 (400 cells) and 3x3 mm^2 (3600 cells) respectively. These features were measured by exciting the sensors by means of 420 nm light from a pico-laser with 32 ps pulse duration and rms jitter better than 3 ps. The time resolution has been studied in correlation to the number of detected photoelectrons. For pulses produced by a single-photoelectron, timing values of 400 and 1100 ps FWHM, for the 400 and 3600 cell photodetectors respectively, have been measured at the overvoltage (OV) of 28V. The dependence of these values on OV and their trade-off with the dark count rates will be shown. Problems connected with the afterpulse effect have been avoided counting the detected photoelectrons with a peak sensing digital converter. Excess noise factors of 1.005 and 1.03 have been measured for the 400 and 3600 cell MCCPs respectively, which allow a single photoelectron resolution up to a total number of 20 and 2, respectively, with a 3σ power. The results have relevance for the possible use of these photodetectors in ring imaging Cherenkov detectors (RICH).

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The transfer RIB lines to the DESIR facility at GANIL-SPIRAL2

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The new ISOL facility SPIRAL2 is currently being built at GANIL, Caen France. SPIRAL2 will produce a large number of new radioactive ion beams (RIB) at high intensities. These beams will be produced using a new linear accelerator that will deliver deuterons up to 40MeV at 5mA intensity, protons up to 33MeV at 5mA and ions with A/Q=3 up to 14.5MeV/u at 1mA. The DESIR (Désintégration, excitation et stockage des ions radioactifs = Decay, excitation and storage of radioactive ions) facility will receive by mid 2018 beams from the SPIRAL2 production cave where fission of ^{238}U nuclei, fusion-evaporation, nucleon transfer as well as deep-inelastic reactions will take place. Additionally, RIB from the S3 separator spectrometer of SPIRAL2 will be delivered to DESIR. They will be produced in fusion-evaporation, transfer and deep-inelastic reactions, and will notably consist in refractory elements. Finally beams from the existing SPIRAL1 facility will also be available at DESIR (see fig. 1).

Nuclear physics as well as fundamental weak-interaction physics and astrophysics questions will be addressed using laser spectroscopy techniques, decay spectroscopy of radioactive species, mass spectrometry and other trap-assisted measurements. Experience at other ISOL facilities evidences that ion beams with a high degree of purity are needed to push experiments towards the limits of stability.

In order to deliver the RIB to the experimental set-ups installed in the DESIR hall, 110 meters of beam line have to be designed, originating from 3 different facilities. The maximum beam energy will be 60 keV and its transverse maximum geometric emittance will be 80π.mm.mrad at ±2RMS. Only mono-charged particles will be transported therefore using electrostatic optical devices will be a great advantage. This paper will focus on the studies which have been done on these transfer lines: beam optics and errors calculations, quadrupoles, diagnostics and mechanical designs …

Figure 1: *Scheme of the new SPIRAL2 facility at GANIL Caen France*

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VANDLE-izing North America; First Results from the Versatile Array of Neutron Detectors at Low Energy

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The Versatile Array of Neutron Detectors at Low Energy was designed to measure energy-resolved neutron spectra using the time-of-flight technique. With over 100 small and 100 large neutron detector modules (60 cm and 200 cm), VANDLEs versatility and unique capabilities enable the design of experimental setups optimized to achieve a variety of research goals at select accelerator labs.

This array was successfully commissioned in an experiment measuring the beta-delayed neutron spectra of over 30 fission fragments at Oak Ridge National Lab (ORNL). A proton transfer (d,n) experiment on ^{56}Ni will measure the proton width for the strongest bottleneck in the rp process of explosive nucleosynthesis. This experiment is in conjunction with the MoNA/LISA array at the National Superconducting Cyclotron Lab at Michigan State University. Preliminary results from the commissioning experiment as well as data from the proton transfer (d,n) experiment will be presented. I will also present our plans to use VANDLE for experiments at the University of Notre Dame and ORNL measuring the ^{19}F(α,n) cross section, important for nuclear nonproliferation efforts.

This work is supported by the US Department of Energy Office of Science, the National Nuclear Security Administration, and the US National Science Foundation.

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Prototype testing, characterization and complementary simulations for the forthcoming CALIFA Barrel calorimeter

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CALIFA is a calorimeter proposed for the detection of γ-rays and light charged particles originating from nuclear reactions induced by relativistic beams. It is one of the key detectors of R^3B (Reactions with Relativistic Radioactive Beams @ FAIR, Darmstadt), a setup designed for experimental reaction studies with exotic nuclei far from stability, with an emphasis on astrophysics, nuclear structure and applications [1].

The requirements imposed on the CALIFA calorimeter reflect the wide spectrum of experiments to be performed employing this versatile setup. In certain spectroscopic physics cases, a high gamma energy resolution (~5% at 1 MeV) and multiplicity determination is requested. In others, the goal is to obtain a calorimetric response with high efficiency. Part of the complexity arises from the kinematics of the reactions, producing a large Lorentz boost and broadening, the correction of which should be accounted for by the detector [2]. Charged particles of moderate energy, for instance protons up to 300 MeV, should be identified with an energy resolution superior to 1%.

CALIFA consists of two sections: a 'Forward EndCap' and a cylindrical 'Barrel' covering an angular range from 43.2 to 140.3 degrees. The Barrel section, based on long CsI(Tl) truncated pyramidal crystals coupled to large area avalanche photodiodes (LAAPDs), attains the requested high efficiency for calorimetric purposes using a carbon fibre alveolar support structure with a minimum of interposed matter [3]. Several prototypes have been developed based on the solutions proposed for the scintillator material, light readout photodiodes, wrapping materials each corresponding to different kinematic regions of the CALIFA detector. The construction of the CALIFA Demonstrator, amounting to 20% of the total detector, has already been initiated, and commissioning experiments are expected for the beginning of 2014 [3].

The present report summarizes the results obtained in several tests performed for the evaluation of the γ-rays and light charged particles detection. An investigation into detector performance regarding high energy gamma rays was undertaken at the Maier Leibnitz Laboratorium, Garching, Germany, where a carbon target was irradiated with protons, amongst the decays being that of the 1_2^+ to ground state via 15.1 MeV photon emission. The prototype was further probed with high energy protons via a deuteron beam at energies ranging from 200 to 600 MeV at a recent experiment undertaken at GSI, Darmstadt, Germany. A separate prototype corresponding to a different section of the CALIFA geometry was tested using a 170 MeV proton beam at the Svedberg Laboratoriet, Uppsala, Sweden. Results from this experimental campaign will be discussed in light of simulated data obtained for the entire Barrel section and the configuration of the prototypes, their performance extrapolated to the wider calorimeter.

[1] Technical Proposal for the Design, Construction, Commissioning and Operation of R3B, universal setup for kinematical complete measurements of Reactions with Relativistic Radioactive Beams. FAIR-PAR/NUSTAR/R3B, December 2005.
Available at http://www-land.gsi.de/r3b/docu/R3B-TP-Dec05.pdf
[2] H. Alvarez-Pol *et al*, Nucl. Instr. and Meth. Phys. Res. B **266** (2008) 4616 - 4620.
[3] A Technical Report for the Design, Construction and Commissioning of The CALIFA Barrel: The R3B CALorimeter for In Flight detection of γ-rays and high energy charged pArticles.
Available at http://igfae.usc.es/~r3b/documentos/TDR/CALIFA_BARREL_TDR.pdf

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Sailing to the Island of Stability with S^3

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The stability of nuclei beyond the spherical double shell closure of ^{208}Pb rapidly decreases because of the disapearance of the macroscopic fission barrier. This phenomenon is however compensated by quantum shell effects caused by the high density of orbitals around the Fermi level. This concentration of levels holding widely different spin projections causes the appearance of deformed gaps responsible for the stabilization of nuclei in the transfermium region. The Island of Superheavy Stability is foreseen as a doubly spherical gap whose position varies depending on the model used [1,2].

Spectroscopy in the region of high masses is very close to the limits of the existing detection systems. The extension of the investigation on nuclear structure to heavier nuclei is governed by an improvement in the efficency of the transport and selection of the nuclei of interest as well as in the detection systems.

Research on this region has restarted at GANIL in preparation of the first phase of the SPIRAL2 project at GANIL that will see the production of very high intensity stable beams from the LINAC accelerator. The Super Separator Spectrometer S^3 is designed to use these beams with the best achievable efficiency [3]. The very high intensity beams provided by the LINAC, combined with the high transmission and selection power of S^3, will provide an unprecedented access to nuclei with cross-sections in the nanobarn region.

SIRIUS (Study and Identification of Recoiling Ions Using S^3) will be the detection system dedicated to spectroscopy experiments for superheavy nuclei with S^3. It is currently developped to study the structure of very heavy and superheavy nuclei, the synthesis of superheavy nuclei as well as the spectroscopy of nuclei in the ^{100}Sn region. Using the latest technologies, the S^3 collaboration is designing a state of the art separator-spectrometer and detection system based on recoil-decay tagging to provide the best possible efficiency for these physics cases.

This contribution will develop the Physics program for the study of superheavy nuclei at GANIL and SPIRAL2 as well as the technical developments for S^3.

[1] M. Bender *et al.*, Phys. Lett. B510 (2001) 42.
[2] S. C̀wiok *et al.*, Nucl. Phys. A573 (1994) 356.
[3] A. Drouart *et al.*, Nucl. Phys. **A834** (2010) 747c.

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The SPES project at the INFN- Laboratori Nazionali di Legnaro

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The SPES Radioactive Ion Beam (RIB) facility at INFN-LNL is in the construction phase.
It is based on the ISOL method with an UCx Direct Target able to sustain a power of 10 kW. The primary proton beam is delivered by a high current Cyclotron accelerator, with energy 35-70 MeV and a beam current of 0.2-0.5 mA. Neutron-rich radioactive ions will be produced by proton induced Uranium fission in a UCx target at an expected fission rate in the target in the order of 10^{13} fissions per second. The exotic isotopes will be re-accelerated by the ALPI superconducting LINAC at energies of 10 AMeV and higher, for masses in the region of A=130 amu, with an expected rate on the secondary target of $10^7 – 10^9$ pps. The SPES project has the aim to provide high intensity and high-quality beams of neutron-rich nuclei as well as to develop an interdisciplinary research center based on the cyclotron proton beam.

The general overview and the status of the project will be presented.

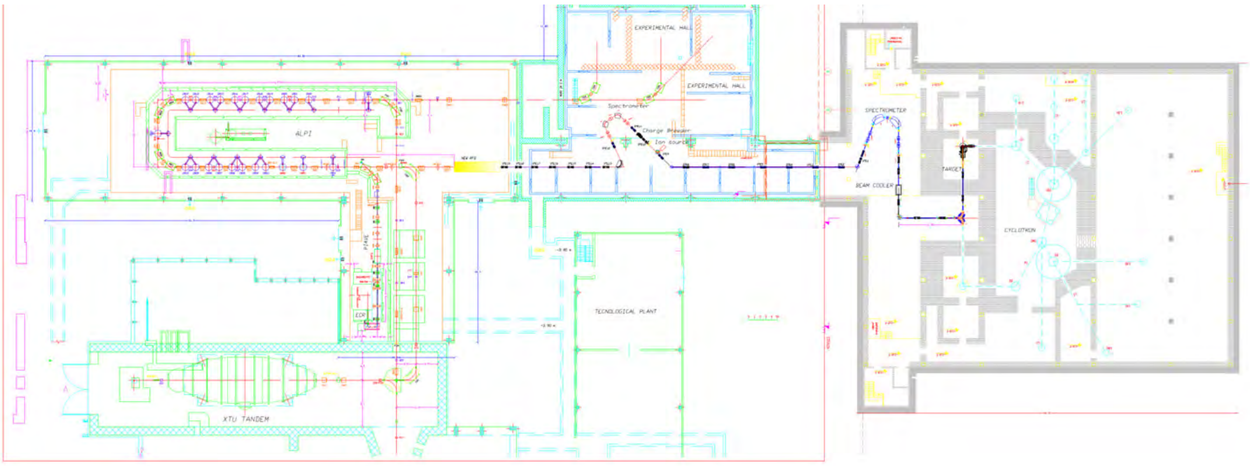

Figure 1: *Layout of the SPES ISOL facility*.

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Pellet tracking system for hadron physics experiments

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Frozen microspheres of hydrogen, so called pellets, are used as targets in the hadron physics experiment WASA (Forschungszentrum Jülich, Germany) [1] and will also be used in the future PANDA experiment at FAIR (GSI, Darmstadt, Germany) [2].

Pellets have a diameter of 25-30 μm. They are generated 2 - 3 meters above the interaction region, to which they travel inside a thin pipe (the space between pellet generation point and the interaction point is occupied by the particle detector system). The distance between the pellets is in the order of a few millimeters and they form a stream of a few millimeters in diameter. The interaction region is given by the overlap of the pellet stream and the accelerator beam and has a size of a few millimeters.

One would like to know the interaction point more precisely, to have better possibility to reconstruct the particle tracks coming from the reaction point. One would also like to suppress background events that do not come from a pellet, but e.g. may occur in rest gas, that is present in the beam pipe.

A solution is provided by the presented pellet tracking system, for which a prototype [3] has been developed at Uppsala Pellet Test Station (The Svedberg Laboratory, Uppsala, Sweden). The goal of the system is to track single pellets in order to know their position at the time of an interaction. The desired resolution is a few tenths of a millimeter. The tracking will be realized using lasers and fast line-scan (i.e. one dimensional) CCD cameras. The cameras, placed at different levels along the pellet stream, will measure pellets position and time of passage (Figure 1). Then, the information from many cameras will be put together to identify and reconstruct the track of each pellet. Information about the pellet position in the interaction region at the time of an interaction will be used in the analysis of the experimental data.

To be useful, the tracking system must be highly efficient and provide tracking information for essentially all pellets that pass the interaction region. The design of such a system, simulation techniques and results will be presented.

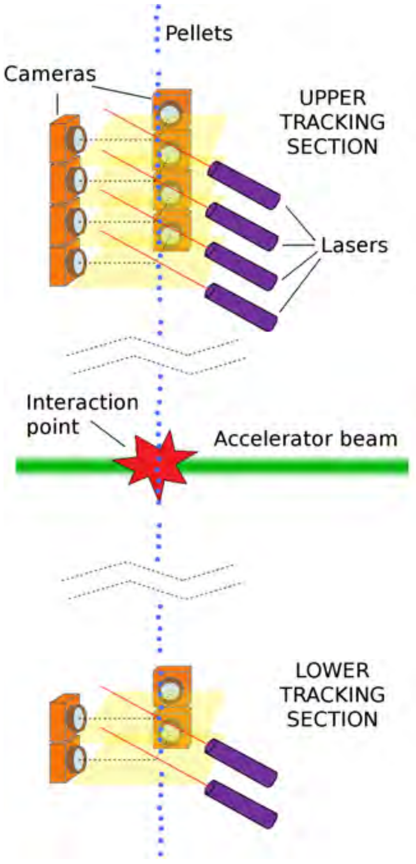

Figure 1: *Principle of operation of a pellet tracking system*

[1] WASA-at-COSY Collaboration: H.-H. Adam *et al.*, *arXiv:nucl-ex/0411038* (2004).
[2] Physics Performance Report for PANDA: Strong Interaction Studies with Antiprotons, W. Erni *et al.*, PANDA Collaboration, *http://arxiv.org/abs/0903.3905v1* (2009).
[3] H. Calén *et al.*, Forschungszentrum Jülich IKP Annual Report, (2011).

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Target thickness dependence of the Be(p,n) neutron energy spectrum

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Measurements of the produced neutron field by Be(p,n) converters of different thicknesses with a 30 MeV proton beam have been performed at The Svedberg Laboratoriet (TSL), Uppsala (Sweden). The aim of the measurements is to characterize and compare the various spectra created by these targets. The setup will be used at the IGISOL-JYFLTRAP facility (University of Jyväskylä), with a new high current light ion cyclotron to create fast neutron spectra for studies of produced neutron rich nuclei, and of neutron induced independent fission yields of various actinides. For this purpose we plan to use a series of mass separating elements, culminating with the JYFLTRAP Penning trap, where a mass resolving power ($M/\Delta M$) in the order of a few hundred thousands can be achieved [1,2].

In order to study the energy dependence of fission yields, mono-energetic neutron beams are desired. Thin targets however, result in lower neutron yields and therefore thick targets are preferred, although resulting in white neutron spectra. The energy dependence of fission yields can then be obtained by varying the thickness of the converter or the energy of the incident ion, followed by an unfolding procedure.

As a result, we here present the comparison of the detected neutron energy spectra, obtained with 30 MeV protons on Be targets of three different thicknesses (1, 5, 6 mm), measured with the Time of Flight technique using a BC-501 liquid scintillator with good n-γ Pulse Shape Discrimination (PSD) properties [3]. Detected events were recorded simultaneously by two independent DAQ systems, an analogue one with preset threshold and hardware PSD, and a digital one where the complete waveforms were saved for off-line pulse shape analysis. In order to ensure good energy resolution over the entire measured interval and to minimize the wrap-around effect given by the time structure of the cyclotron at TSL, the detector was positioned at three different distances from the target. Monte Carlo simulations of the respective conditions have been performed with Fluka and MCNPX codes, and a comparison with the experimental results will also be presented.

[1] H. Penttilä, P. Karvonen, T. Eronen et al, The European Physical Journal A 44 (2010) 147-168;
[2] J.Äysto, Nuclear Physics A 693 (2001) 477-494;
[3] S.E. Arnell, H.A. Roth, O. Skeppstedt et al, Nucl. Instr. and Meth. in Phys. Res. A 300 (1991) 303-311;

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Front-End electronics for the FAZIA project

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The FAZIA project

FAZIA is a multidetector whose purpose is to identify the nature of charged particles by measuring their masses and their energies. This multidetector will cover the full angular space of 4Π with 10000 tiles. Each tile is called a telescope. It is a detection cell composed of three detectors. Two of them are made of silicon. The last one is a CsI scintillator associated to a photodiode. The objective is to obtain identification for charges up to Z=70 and masses up to A = 50. This goal will be reached using novel pulse shape analysis techniques making an intensive use of high speed flash ADCs with rates up to 250 Ms/s and 14 bits resolution. The telescopes are gathered by blocks of 16. So each block embeds 16 telescopes together with the front-end electronic instrumentation. The whole block is placed in the vacuum chamber and communicates with the outside world via an optical fiber. The block is powered from outside with a 48V power supply. All the internal supply voltages are built from the 48V inside the block. The advantage to embed the electronic instrumentation with the telescopes is to get rid of 60000 cables which would have made the mounting complicated. But it is a real challenge because of two reasons. First, the electronic components have to resist to a vacuum environment. And second because the cooling of the electronic devices cannot be realized by air anymore. A water cooling system has to be built in and it has to be able to dissipate 200 W of heat for each block.

Structure of the electronic instrumentation embedded in the block

The block is composed of 16 telescopes, 8 front-end cards, a block card, a power-supply card and a main board.

The purpose of a telescope is to provide electrical signals related to the mass and the energy of a charged particle which hits it. The telescope is a metallic frame which contains two silicon layers and a CsI scintillator associated to a photodiode. In the frame, these 3 layers are assembled vertically one behind the other. The silicon detectors are placed in the front line and their area is 20x20 mm². The thickness of the first silicon detector that the charged particle will hit is 300 µm. The thickness of the second one is 500 µm. The CsI layer which is the last detector has a thickness of 100 mm.

The purpose of each front end card is to amplify and to digitize the signals coming from the detectors of two telescopes. When the energy of the signals is greater than a threshold value, the FEE card sends a request to the block card which will answer later with a validation signal. Then, the FEE card will consider this energy overrun as an event. The card will send all the data of this event to the block card. These tasks constitute the acquisition function of the FEE card.

The block card manages the 8 front-end cards which generate the acquisition requests when events occur. The block card responds by sending the validation signals to the FEE cards. The block card receives also some acquisition data at high speed (400 Mbits/s).

From a 48V voltage provided from outside, the power-supply card builds a set of low voltages required for the block card and the eight FEE cards.

The main board is required to connect together the eight FEE cards, the block card and the power supply card.

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CEPA: A $LaBr_3(Ce)/LaCl_3(Ce)$ phoswich array for simultaneous detection of protons and gamma radiation emitted in reactions at relativistic energies

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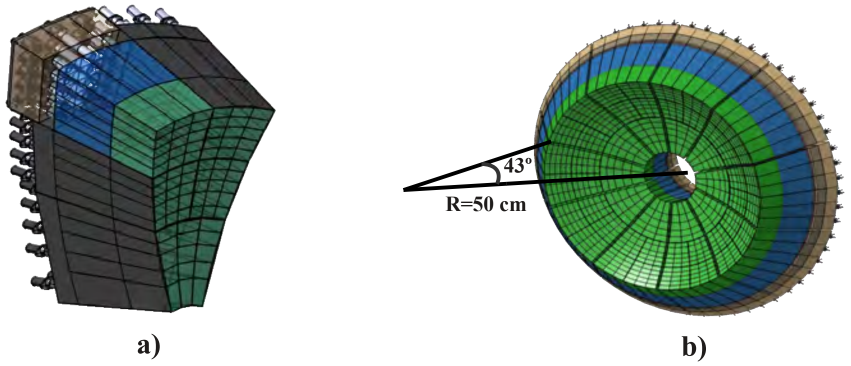
Detectors made of fast scintillator materials, properly segmented for Doppler correction and adapted to a high level of electronics and mechanical integration are more and more needed to study reactions at relativistic energies. Concerning these needs we have designed an array of $LaBr_3(Ce):LaCl_3(Ce)$ phoswich crystals placed at 50 cm distance from the reaction-target. They cover the region beteen 7º and 43º and concentrate a major part (more than 50 %) of the γ rays emitted by the fragments moving at a 80% of the speed of light [1].

The CEPA detector is divided into 10 branches of 5 alveoli each. These alveoli are sub-divided into 15 slots to hold individual phoswich crystals. Each phoswich unit is made of a 4 cm long $LaBr_3$ crystal optically coupled to a 6 cm long $LaCl_3$ crystal. In total CEPA includes such 750 individual crystals. They are in the form of truncated pyramids, with bases sides that depend on the polar direction and designed to obtain an energy resolution of 3.75 %, using the reaction parameters mentioned above. This segmentation obeys the geometrical read-out considerations (area of the photomultipliers): (1.2-3.5) cm for the inner base side and (1.7-4.5) cm for the outer one. The active detection coverage of the CEPA detector for the mention solid angle is more than 80% .

The crystal length of 10 cm was optimized according to Montecarlo simulation results. CEPA was implemented in R3BRoot [2] and efficiencies and resolutions were simulated for high energy gamma radiation (0.5-30 MeV) and protons (up to 700 MeV). In the case of protons the two-layer detector can be used as a $\Delta E_{LaBr3} - E_{Tot}$ telescope or if very high energies as a double energy loss detector ($\Delta E_{LaBr3} + \Delta E_{LaCl3}$) in order to determine the initial energy [3].

Experimental results obtained with a prototype detector are in agreement with the simulations.



a) b)

Figure 1: *CEPA a) branch design and b) whole design with the mechanical structure*

[1] Technical design of the CALIFA/R3B. GSI, SCIENTIFIC REPORT 2011. 177-180.
[2] http://fairroot.gsi.de/
[3] O. Tengblad et al., Nuclear Instuments and Methods. A 704, 19-26 (2013).

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MARA recoil-mass separator at JYFL – status, instrumentation and performance modelling

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The recoil-mass spectrometer MARA at the Accelerator Laboratory of the University of Jyväskylä (JYFL) will be a compact recoil mass spectrometer for studies of fusion-evaporation residues at the N≈Z line. It has an unique ion-optical configuration – a quadrupole triplet followed by an electrostatic and a magnetic sector field. At the focal plane, a typical first order mass-resolving power of 300 is achieved according to ion-optical calculations.

The aperture and mass slits, vacuum gate valves, power and high-voltage supplies of the magnets and electrostatic deflector are controlled from the same industrial automation system which is used for K130 cyclotron and beam lines in JYFL. An overview of the control system will be given. The mechanical focal plane construction is highly modular which allows an optimized detector setup to suit the varying experimental requirements. The preamplifiers of the silicon detectors are optimized to give a wide energy range when used with digital ADC units. Tests with the preamplifiers and ADC's have shown that the conversion electron, alpha emission and fission fragment energies can be fitted in the same linear energy spectrum with a reasonable electron resolution. The preamplifiers allows an easy gain selection between predefined set of gains.

The mass spectrum of a fusion-evaporation reaction is often very complicated due to many open fusion channels in the reactions producing N≈Z nuclei. A user-friendly program has been developed for calculation and optimization of ion-optical properties of fusion-evaporation reactions. In addition to the focal plane setup, auxiliary detectors at the target position will be used. For example, feasibility studies of MARA combined with a prompt charge-particle veto detector will be presented for different kinds of reaction kinematics. An overall status report of the MARA construction will be given.

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Status of the SPIRAL2 facility

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The SPIRAL 2 facility [1], an ambitious extension of the GANIL accelerator complex, has entered recently in the construction phase. In the frame of this project, a new superconducting linear accelerator delivering high intensity, up to 40 MeV, light (proton, deuteron, $^{3-4}$He) beams as well as a large variety of heavy-ion beams with mass over charge ratio equal to 3 and energy up to 14.5 A.MeV will be constructed in the coming two years (SPIRAL2 Phase 1). Using a dedicated converter and the 5 mA deuteron beam, a neutron-induced fission rate is expected to approach 10^{14} fissions/s for high-density UC_x target. The versatility of the SPIRAL 2 driver accelerator will also allow using fusion-evaporation, deep-inelastic or transfer reactions in order to produce very high intensity Rare Isotope Beams and exotic targets. The energies of accelerated RIB will reach up to 7-8 A.MeV for fission fragments and 20 A.MeV for neutron-deficient nuclei (SPIRAL2 Phase 2).

The physics case of SPIRAL 2 based on the use of high intensity Radioactive Ion Beams and stable light- and heavy-ion beams as well as on possibilities to perform several experiments simultaneously will be discussed and illustrated with recent high-light results obtained at GANIL/SPIRAL. In particular, it will be shown that a use of these beams at the low-energy ISOL facility (DESIR) and their acceleration to several MeV/nucl. as well as of high neutron flux at the n-tof like facility will open new possibilities in study of heavy and super-heavy nuclei, in nuclear structure physics and nuclear astrophysics and in reaction dynamics studies. This exciting scientific program as well as relatively moderate intensities and high cost of radioactive beams impose a use of the most efficient and innovative detection systems as the magnetic spectrometer VAMOS, the 4Π gamma-array EXOGAM2 and AGATA as well as charged particle detectors like MAYA, MUST 2 and TIARA. Several new concepts of the detection systems (ACTAR, DESIR, FAZIA, GASPARD, PARIS) and a new separator/spectrometer S3 located in dedicated experimental halls are currently under construction or design.

[1] 1. http://pro.ganil-spiral2.eu/

International Nuclear Physics Conference INPC2013: 2-7 June 2013, Firenze, Italy

Studies of neutron-rich isotopes at the CARIBU facility

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A new facility for the production of short-lived neutron-rich isotopes, CARIBU, is now operational at Argonne National Laboratory. CARIBU, the Californium Rare Ion Breeder Upgrade (CARIBU) of the ATLAS superconducting linac facility, provides low energy and reaccelerated neutron-rich radioactive beams to address key nuclear physics and astrophysics questions. These beams are obtained from fission fragments of a ^{252}Cf source, thermalized and collected into a low-energy particle beam by a large helium gas catcher, mass analyzed by an isobar separator, and charge breed to higher charge states for acceleration in ATLAS. The approach employed at CARIBU is fast and universal and short-lived isotopes are extracted with a yield essentially following the Californium fission distribution. The facility has ramped up with operation first with a 2.5 mCi source, followed by an 80 mCi source and now a 300 mCi source which has yielded extracted low-energy mass separated radioactive beams at intensities in excess of 2 X 10^5 ions per second. An upgrade to a full 1Ci source is expected later this year. Radioactive beams have been charge bred with an efficiency of about 12% and reaccelerated for experiments at or above the Coulomb barrier. Over 70 neutron-rich species have been extracted and used for experiments so far. The facility will be described and first results from measurements at low energy and with reaccelerated beams will be given. The ongoing PAC approved program will also be presented.

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The solid state laser system for ionization of the SPES radioactive isotopes

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Nowadays the resonant ionization by tunable lasers (also known as LIS, laser ion source) is the most suitable ionizing system to assure a good selectivity directly in the initial phase of the ion production in an ISOL (Isotope Separation On Line) facility

Keeping into account the other experiences from all the ISOL facilities spread into the world, this ionization technique is planned to be used also in SPES (Selective Production of Exotic Species) facility, that will be built in Laboratori Nazionali di Legnaro (LNL – National Laboratory of Legnaro) in Italy by INFN (Istituto Nazionale di Fisica Nucleare – National Institute of Nuclear Phisics).

Studies of laser ionization technique in support of SPES project has started in 2009 in Laser Spectroscopy Laboratory of Pavia with dye lasers and nowadays, at the beginning of 2013, an offline laser laboratory will be constructed in LNL to continue studies of photoionization using an all solid state lasers solution.

The all solid state solution is a recent approach respect to the dye laser to develop a ionization laser system and has to be investigated to reveal its strength points and also its weakness; this will be the aim of the new laser laboratory in LNL.

All this efforts are finalized to be ready with an operative solution and equipment for the first SPES ion beam for the users planned for 2017.

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Unique experiments at the frontiers of nuclear physics: the experimental program for the Super-FRS

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The superconducting fragment separator (Super-FRS) is the magnetic high-resolution spectrometer, which is coupled to the heavy-ion synchrotron complex at FAIR. It is the central device of the NuSTAR collaboration and provides relativistic beams of exotic nuclei ranging from hydrogen to uranium. With intense primary beams in the range of 1000 A MeV, universal isotope production mechanisms (fragmentation, fission, spallation) and in-flight separation at a maximum magnetic rigidity of 20 Tm, high momentum resolution capability up to $p/\Delta p \sim 20.000$ in the dispersion-matched mode, strong background suppression (due to a multiple-stage separation scheme) and specialized detector systems, the Super-FRS allows for a variety of unprecedented nuclear physics experiments, which are not possible elsewhere in the world. Key examples for the envisaged experimental program will be presented, for instance the production and study of exotic hypernuclei (i.e.: nuclei far-off stability containing hyperons) [1], the production and study of mesic atoms (i.e.: atoms containing bound mesons, like pions or eta mesons) [2], direct measurements of in-medium mass shifts [3], the discovery of new neutron-rich isotopes [4], the search for new phenomena in weakly bound or dilute nuclear systems, and the search for neutron radioactivity [5], an elementary radioactive decay mode which was not discovered so far. These experimental goals are intimately connected with the development of dedicated separation schemes and novel detection concepts, and it is the challenging goal of the Super-FRS collaboration to prepare and carry out these unique experiments.

[1] C. Rappold et al., Nucl. Phys. A881 (2012) 218.
[2] T. Yamazaki et al., Z. Phys. A355 (1996) 219.
[3] K. Itahashi et al., Prog. Theor. Phys. 128 (2012) 601.
[4] J. Kurcewicz et al., Phys. Lett. B717, (2012) 371.
[5] L. Grigorenko et al., Phys. Rev. C84 (2011) 021303.

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The tagged photon facility at the MAX IV Laboratory

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The MAX IV Laboratory is a National Infrastructure for research in a many areas with synchrotron radiation from three storage rings. One of these rings, MAX I, may also be operated as a stretcher ring to produce an extracted electron beam, with a duty factor > 0.5, used for studies of nuclear and nucleon properties. The electron beam, with energies in the range 140 – 225 MeV, is used to produce bremsstrahlung. The scattered electrons are momentum analyzed in a magnetic spectrometer with a 62 channel scintillation hodoscope placed in the focal plane of the magnet. The photon energy is determined from the difference between the incoming and scattered electrons. Photons may be tagged from about 15 to 200 MeV with two separate magnets covering different parts of the bremsstrahlung spectrum. Photon intensities of 1 MHz per MeV may be obtained with a photon energy resolution of about 300 keV. The experimental equipment includes 3 large NaI(Tl) spectrometers, each with a diameter of about 28 cm and a length of 60 cm used to investigate Compton scattering in deuterium and in light nuclei. Charged particle $\Delta E - E$ telescopes were used to study the (γ,π^+) reactions in H, ^{2}H and ^{12}C as well as in heavy nuclei. The total photo-absorption cross section in ^{4}He and in ^{6}Li and ^{7}Li, was investigated with different detector systems. For ^{4}He a gas-scintillator active target operated at a pressure of 20 bar was used. For the Li samples the total photo-absorption cross section was measured using the flux attenuation method. Coherent bremsstrahlung is produced in a 0.1 mm thick diamond crystal placed in a goniometer. The degree of polarization is about 30 % for photon energies around 60 MeV for 192 MeV incident electrons. This beam has been used to study the asymmetry in the ^{12}C(γ,p) reaction. The tagged photon beam was also used to study the response of PWO crystals to photons below 100 MeV. An overview of the tagged photon facility and the experimental program will be given.

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Multi-reflection time-of-flight mass spectrograph for extremely fast, high-precision mass measurements

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Atomic mass measurements play a vital role in nuclear physics, providing a direct measure of the nuclear binding energy. Systematic mass measurements provide vital inputs for nuclear structure and nuclear astrophysics. It is currently popular to use Penning trap mass spectrometers for such measurements. However, the nuclei amenable to such a technique is limited by the observation time required for short-lived heavy nuclei such as r-process nuclei and trans-uranium elements. To overcome this limitation, we have developed a multi-reflection time-of-flight mass spectrograph (MRTOF)[1] to perform high-precision mass measurements on even very short-lived heavy nuclear species.

Our MRTOF is capable of achieving mass resolving powers approaching R_m≈200,000 extremely quickly. The figure exemplifies the speed and accuracy of this technique using the close isobaric doublet of ^{40}Ca$^+$ / ^{40}K$^+$. The doublet is fully resolved within 2.3 ms and the mass of ^{40}Ca is accurately determined with a relative uncertainty of $\delta m/m$=7.7×10^{-8}. By way of comparison, a typical Penning trap with a 6 T magnet would require an observation time exceeding 70 ms to perform the same measurement.

We will describe recent online and offline tests with the MRTOF as well as planned mass measurement campaigns for r-process and trans-uranium nuclei at RIKEN/SLOWRI.

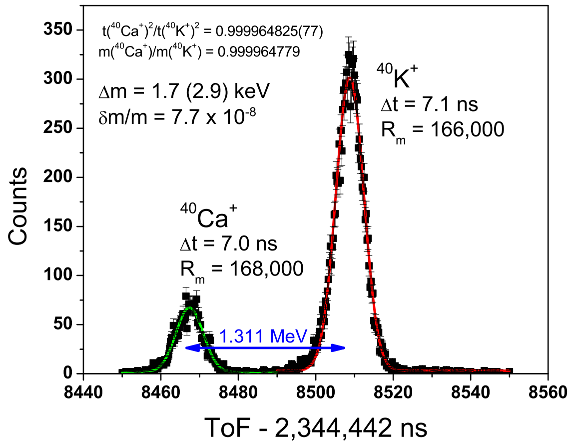

Figure 1: *Time-of-Flight spectrum of* ^{40}*Ca*$^+$ / ^{40}*K*$^+$ *doublet.*

[1] P. Schury et al., Eur. Phys. Jour. A 42 (2009) 343.

Progress of the New International Facility FAIR

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The Facility for Antiproton and Ion Research in Europe, FAIR, is the largest basic research project on the roadmap of the European Strategy Forum of Research Infrastructures (ESFRI). It will be a cornerstone of the European Research Area, with strong participation also from outside the European Union, in particular from Russia and India. FAIR will provide unique accelerator and experimental facilities with exceptional research opportunities, broader in scope than any other contemporary large-scale facility worldwide.

More than 2500 scientists from all over the world will push the frontiers of our current knowledge in nuclear, hadron, atomic, plasma and applied physics, with important implications also for other fields of science such as cosmology, astro- and particle physics, and technology and innovation.

This presentation presents the progress of the FAIR project and outlines the strategy of its realisation towards commissioning and first beams in 2017/2018.

International Nuclear Physics Conference INPC2013: 2-7 June 2013, Firenze, Italy

Commissioning of DSSSD silicon detectors for experiments with Radioactive Ion Beams: a comparative study of ASIC and "traditional" electronics.

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Experiments with low intensity Radioactive Ion Beams call for high efficiency and granularity particle detectors. In beam commissioning runs with Double Sided Silicon Strip Detectors (DSSSD: 64*64 mm^2 area, 32 strips per side) were undertaken in the system ^{17}O→(^{208}Pb+^{58}Ni), E_{17O} 40-50MeV and 76-87MeV, beam currents ~1 pnA, all detectors at 110 mm from the target, total counting rate <1kHz, pulse height analysis via 12bits multisampling homemade ADC. The detectors were arranged as follows: A) 300µm thick, spanning θ_{lab}= [-35°, -65°], ASIC electronics (2 chips per side: VA32HDR14.2, slow 2µsec shaper, and TA32CG.3, fast timing leading-edge type, by Gamma Medica IDEAS, Norway), B) 300µm, θ_{lab}= [+35°, +65°], C) 40µm, θ_{lab}= [+95°,+125°]. The set up B and C utilized traditional, homemade electronics, consisting of a very compact Printed Circuit Board housing 16 Preamplifiers, installed in vacuum very close to the detector, and a 16 channel multi-detector Pulse Shape Amplifier with Serialized Readout and CF timing. This set up requested to connect the 32 DSSSD strips connected 2 by 2. The ASIC type electronics has the advantage to feed into the ADC just one signal per each DSSSD side. On the other hand traditional electronics has the advantage to match various detector capacitance and an accurate timing. Examples of typical comparative results are plotted below. Fig.1 compares in beam single strip spectra at 50MeV ^{17}O, detector A: -50° (B: +50°), energy resolution ΔE/E < 1%. The C detector had an overall resolution ΔE/E ~3.5%, including kinematics spread. Fig.2 shows the ratio $d\sigma/d\sigma_{Ruth}$ for ^{17}O scattered by ^{58}Ni at 50MeV measured in two separate experiments. The two data, plotted with red (only down to 75°) and blue points, are very well overlapping. Detailed results of the scattering data analysis are presented in separate INPC2013 contribution. A first part of the results were reported in the proceedings of the NN2012 International Conference (SanAntonio, TX, USA). Both techniques are valuable and useful. For large DSSD (thickness ≥300µm) arrays the ASIC chip based approach seems to be more easy and friendly to use.

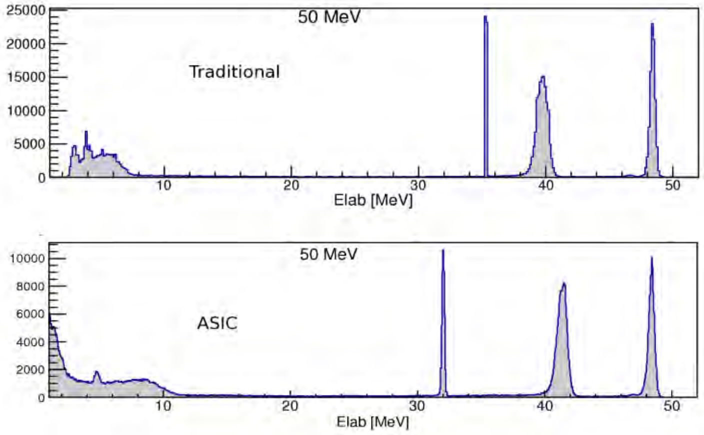

Fig.1: ^{17}O beam energy spectra: pulser ^{58}Ni ^{208}Pb

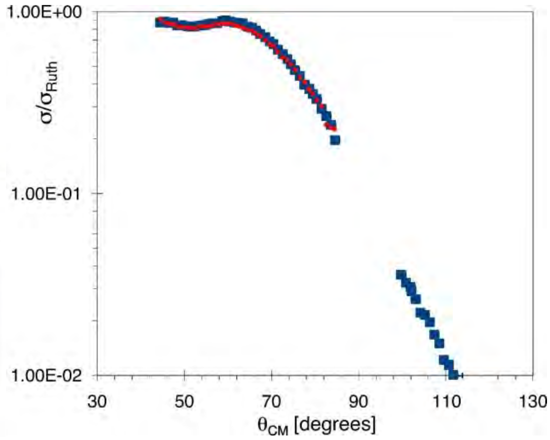

Fig.2: ^{17}O scattering by ^{58}Ni: $d\sigma/d\sigma_{Ruth}$

International Nuclear Physics Conference INPC2013: 2-7 June 2013, Firenze, Italy

Direct mass measurement program of exotic nuclei based on the TOF-P-ΔE method

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Nuclear Mass is one of the most fundamental properties in understanding the origin of elements from Fe to U in our universe. Although lots of efforts have been made in the last two decades [1-3], the progress in precision nuclear mass measurements is still largely limited to lighter nuclides close to the stability line, due to the known problems in production, separation and detection of heavy n-rich nuclides, as well as in finding reliable reference masses. At Beihang University, Beijing and IMP, Lanzhou, we are aiming to develop a new mass measurement program TOF-P-ΔE. The key issue in this new method is to develop a detector system with high resolving power in order to obtain a mass accuracy in the order of 100 keV for interested exotic nuclides. The system consists of a timing detector with precision of around 5 ps, a position-sensitive detector with precision of about 10 micro-meter, and a MUlti-Sampling Ion Chambers for high counting rate. In this contribution, the details and the possible physics of this new mass measurement program will be introduced. The progress on the detector development will be reported with special focus on the fast timing detectors.

[1] D. Lunney, J.M. Pearson, C. Thibault, Rev. Mod. Phys. 75 (2003) 1021.

[2] K. Blaum, Phys. Rep. 425 (2006) 1.

[3] B. Franzke, H. Geissel, G. Mnzenberg, Mass Spectrom. Rev. 27 (2008) 428.

International Nuclear Physics Conference INPC2013: 2-7 June 2013, Firenze, Italy

A new facility for very low cross section measurements

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Stellar nucleosynthesis occurs in stars during the process of stellar evolution. Fusion process is responsible of the formation of light elements between C and Ca. The main fusion reactions in stars cooler than Sun are included in the p-p chain while CNO cycle is dominant for stars hotter than the Sun. Those nuclear reactions occurring in the core of stars are produced in the Gamow energy window, which is located below the Coulomb barrier where the cross sections are very low. It is necessary that nuclear physicists measure the reaction cross sections at very low energies and thus be sensitive to very low reaction rates. In particular for radiative capture reactions, we must determine the optimal experimental conditions to detect the gamma rays. This means making very low background measurements. The present project gives the usual constraints and the solutions we have chosen for the particular $^{13}C(p,\gamma)^{14}N$ resonant reaction that is involved in the CNO cycle and which plays a key role in the nucleosynthesis of heavy elements in AGB stars. The reverse kinematics reaction $^{1}H(^{13}C,\gamma)^{14}N$ have been studied by bombarding an hydrogenated silicon sample with 13C ions in the energy range which corresponds to energies around the 511 keV resonance in the CM system.

The experimental set-up consists of a HPGe detector (138% efficiency) or a 4x4 inches NaI(Tl) well detector installed in a passive shielding. The detector is placed near the target in a lead castle of ultra-low background material, which is covered with a plastic scintillator to detect muons produced in the high atmosphere of Earth. The efficiency of the muons detector has been measured and shows lower background in the energy region of interest of the gamma rays detector. The HPGe detector placed in the lead castle detects 8 MeV γ-rays emitted from the capture reaction $^{1}H(^{13}C,\gamma)^{14}N$, which is the reverse kinematics of the proton capture by ^{13}C occurring in the CNO cycle of stars. In order to reduce the background the gamma rays detector is in anti-coincidence with the muons detector placed above the lead castle.

First results using this very low background facility will be shown and the efficiency of the anti-coincidence technique will be explained in detail. Recently the active shielding has been upgraded to reduce the background due to muons and to measure the $\cos^2\theta$ distribution.

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Development of a Compton Camera for Online Range Monitoring of Laser-Accelerated Proton Beams via Prompt-Gamma Detection*

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Presently large efforts are conducted in Munich towards the development of proton beams for biomedical applications, generated via the technique of particle acceleration from high-power, short-pulse lasers. While so far mostly offline diagnostics tools are used in this context, we aim at developing a reliable and accurate online range monitoring technique, based on the position-sensitive detection of prompt γ rays emitted from nuclear reactions between the proton beam and the biological sample. For this purpose, we develop a Compton camera, designed to be able to track not only the Compton scattering of the primary photon, but also to detect the secondary Compton electron, thus reducing the Compton cone to an arc and by this increasing the source reconstruction efficiency.

Within a wider context, a detector system consisting of several Compton camera modules could also be used in a versatile hybrid mode for range verification of therapeutic (carbon) ion beams. Prompt γ radiation could be detected during the irradiation, while during the irradiation interrupts delayed photons from short-lived β^+ (or β^+-γ) emitter, produced during the irradiation, could be exploited to allow for a PET- or γ-PET mode of operation.

The design of the Compton camera is based on a $\mathrm{LaBr_3}$(Ce) scintillation crystal (50x50x30 mm^3) acting as absorber, preceded by a stack of 6 double-sided silicon strip detectors (DSSSDs) as scatterers. The scintillation material $\mathrm{LaBr_3}$ is favourable in view of its unprecedented fast timing properties (achievable time resolution in the range of several 100 ps), while simultaneously exhibiting good energy resolution. In order to achieve optimum position resolution for the absorbed photon, the scintillation crystal is read out by a (256-fold) segmented multi-anode photomultiplier. The Si scatterers (50x50 mm^2) with an active thickness of 300 μm are 128-fold segmented on each side (pitch size 390 μm). Data readout of the scintillator is performed via individual channels of spectroscopy electronics, while the 1536 signal channels of the Si detectors are processed by highly integrated modules based on ASIC chips.

The contribution will review simulation-based design criteria and performance properties for the Compton camera as well as the present status of the commissioning phase of the prototype detector system.

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The Facility for Rare Isotope Beams

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The next generation radioactive beam facility in the U.S. is the Facility for Rare Isotope Beams (FRIB) which is currently being established at Michigan State University. FRIB is based on a 200 MeV/u 400kW superconducting linear accelerator. Initial capabilities include fragmentation of fast heavy-ion beams combined with gas stopping and reacceleration. The science program of FRIB will cover discoveries about the properties of rare isotopes in order to better understand the physics of nuclei, nuclear astrophysics, fundamental interactions, and applications for society. The final design of the conventional facilities — the tunnel and support buildings — is complete and the final design of the technical systems — accelerator and experimental equipment — is underway and anticipated to be complete in 2014. The present status and future scientific discovery potential of FRIB will be discussed.

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A new real-time detection system for heavy element research

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New detection system design for heavy element research [1,2] with ^{48}Ca projectile has been reported. This system is based on application of 32 position sensitive strip PIPS detector and low pressure pentane filled TOF detector application in ^{48}Ca induced nuclear reactions. To suppress beam associated background products new version of real-time method of "active correlations" has been applied. Examples of applications in ^{249}Bk+^{48}Ca and ^{243}Am+^{48}Ca reactions are presented. The system development to operate together (in parallel) with the digital ORNL detection system to provide a quick search for EVR-alpha correlation chains has been discussed too. In that case the system operates with DSSSD large area Micron Semiconductors detector.

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[1] Y.Oganessian et al., Phys. Rev. Lett. 109, 162501 (2012);

[2] Y.Oganessian et al., Phys.Rev.C. 87, 014302(2013)

International Nuclear Physics Conference INPC2013: 2-7 June 2013, Firenze, Italy

ALTO, the electron-driven ISOL facility in Orsay: status and perspectives

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ALTO (Accélérateur Linéaire auprès du Tandem d'Orsay) is the electron-driven isotope separation on-line (ISOL) system built and operated by the Institut de Physique Nucléaire (IPN) in Orsay. It is dedicated to the production of neutron-rich radioactive beams from the interaction of a 50 MeV 10uA electron beam with a UCx target (~60-70 g of ^{238}U). It is dimensioned for 10^{11} fissions/sec (inside the target-ion source ensemble) and located in the Orsay Tandem premises. RIBs are available after mass separation at the source extraction energy. ALTO is then the first electron-driven photo-fission facility operated in the world. The coexistence of the two machines, Tandem and ISOL, within the same facility, allows a large variety in the research domains which can be addressed, ranging from basic nuclear physics and nuclear astrophysics research, to instrument development or testing, to applications of nuclear techniques.
In year 2012, the ISOL facility received the full green light for operation from the French nuclear safety authorities. A formal inauguration was organized on May 13th 2013 followed by a scientific workshop. Meanwhile, a laser ion source was commissioned and successfully used for the selective ionization of neutron rich Ga isotopes. The development of several other laser ionization schemes is scheduled, starting from Zn in June 2013. In parallel, the available RIB lines are being equipped. A new detection setup based on the use of a movable tape station has been designed and dimensioned to accommodate the 4 small EXOGAM CLOVERs (EXOGAM prototypes). This setup named BEDO (BEta Decay Studies at Orsay) has been optimized for Compton suppression and beta selection, it was fully commissioned on line with radioactive A=83,84 beams. On a second beam line, the On-Line Nuclear Orientation (OLNO) method will be used in a near future to observe the decay of a spin-oriented ensemble of nuclei with the POLAREX (POLARization of EXotic nuclei) setup.

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The mechanical design of the BARREL section of the detector CALIFA for R3B-FAIR.

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The detector CALIFA [1] (CALorimeter for the In Flight detection of gamma-rays and light charged pArticles) is one of the key detectors of the R^3B experiment [2] (Reactions with Relativistic Radioactive Beams) at the facility FAIR [3]. CALIFA will feature a high photon detection efficiency and good energy resolution even for beam energies approaching 1 AGeV, as well as the required calorimetric properties for detection of multiple gamma-ray cascades.

CALIFA consists of two sections, a cylindrical Barrel and a Forward EndCap.The optimum cost-effective solution for the BARREL, covering an angular range from 43.2 to 140.3 degrees, is based on CsI(Tl) crystals whose scintillating properties provide a rather good energy resolution and the density required for high detection efficiency. The BARREL will consist of almost 2000 CsI(Tl) crystals providing the angular resolution necessary to correct the Doppler shift of the gammas emitted in-flight by the reaction products. Extensive studies based in GEANT4 [4] simulations and mechanical calculations with finite elements analysis in ANSYS [5], have been performed, and guided the engineering design to reach its final version. The design optimization was focused in the segmentation (increasing the segmentation helps for the energy resolution, but at the expense of the calorimetric properties), and the structural materials (with the motto 'the less, the better‘ to minimize the energy losses in the passive material, which is especially critic for the energy resolution of the protons).

In this paper we describe the engineering design solution proposed for the BARREL. The CsI(Tl) crystals are supported in an alveolar structure made of **carbon-fiber composites**. The overall design conditions imposed by the project for the active core include: i/ a robust and safe structure; ii/ a minimum of structural material; and iii/ a tight definition of the static positioning and orientation of the active elements. The standing structure must support the active core, allowing for the partition of the system in two autonomous symmetric halves, and the possibility to make a longitudinal shift between the halves to allow for a clearance of the forward angles, as well as helping in the setup of the Forward EndCap. Due to the hygroscopicity of CsI(Tl) crystals, they must be kept in a dry atmosphere. Moreover, the response of the crystal + photosensor (APD) is temperature dependent. To cope with the resolution requirements the active volume will be filled with nitrogen renewed in a closed loop at controlled temperature. That will be accomplished by means of a modular cover of the BARREL that will be a key part of the external structure of the detector.

The construction will start in 2013 with the so called DEMONSTRATOR [6], a structure based in CALIFA mechanical solutions, covering 20% of the detector active elements, and available for physics experiments in 2014 at GSI [7]. CALIFA is expected to be ready for commissioning in 2016.

[1] The technical design report TDR of CALIFA has been approved in December 2012. It will be shortly available for public at the R3B and CALIFA web-sites, http://www.igfae.usc.es/ r3b

[2] R3B, A next generation experimental setup for studies of Reactions with Relativistic Radioactive Beams, http://www.gsi.de/r3b

[3] FAIR, An International Facility for Antiproton and Ion Research, http://www.fair-center.eu

[4] Nucl. Inst. Meth. B, vol. 266, pp. 46164620, 2008.

[5] ANSYS, http://www.ansys.com

[6] A separated paper for the DEMONSTRATOR is submitted, same author-list.

[7] GSI, Helmholtzzentrum für Schwerionenforschung GmbH, Germany.

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Design, construction and test of the structure of the DEMONSTRATOR of the CALIFA detector for R^3B-FAIR, using carbon-fiber composites.

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The detector CALIFA [1] [2] (CALorimeter for the In Flight detection of gamma-rays and light charged pArticles) is one of the key detectors of the R^3B experiment [3] of FAIR. The proposed solution for the BARREL section of CALIFA, is based on more than 2000 CsI(Tl) crystals, oriented within a very compact geometry (with an internal radius of 30 cm).

The engineering design was aided with calculations using finite elements analysis (ANSYS [4]) and simulations (GEANT4 [5]), optimizing both the segmentation of the scintillator active material and the amount of structural material. The solution to support the crystals is based in a honeycomb-like structure made of a carbon fiber composite (CFRP) of epoxy resins. The calculations performed confirm that such structure would accomplish with the physics demands at the active region , as well as the structural needs to support and tightly hold the many crystal units. The amount of passive/structural material is **less than 0.7%** of the mass of the total active region.

The complexity of working with CFRPs is twofold. On the one hand, the constuction is handcrafted in all of the stages to make the proposed structure. That has severe limitations in repeatability, homogeneity, tolerances, assembly procedures, etc. On the other hand, due to the nature of production as well as the anisotropy of the material, the calculations have a limited range of applicability, which can only be validated with real cases. Therefore the feasibility of the proposed design can only be proven after a prototype phase dedicated to demonstrate the procedure for making the structure (material, fabric, presentation, cast design, curation cycle, end finishing, etc., as well as the procedure for mounting the structure), and then to evaluate the structure properties (metrology and mechanical tests).

The DEMONSTRATOR consists in a collection of structures called PETALs. Each one consists of a bundle of CFRP pieces corresponding to a representative region of the CALIFA design. The PETAL mechanical structure is mimic to that of the CALIFA. The production procedures and tools developed for the PETALs will serve to solve the production procedures for CALIFA. In this paper we show **the status of the construction of the PETALs**, with the solutions for making the CFRP structure.

The construction of the DEMONSTRATOR started in 2012, and will follow through 2013-14 with the addition of functional PETAL structures, till covering the 20% of the detector active elements. By 2014 the system should be ready for physics experiments at GSI [6].

[1] The technical design report TDR of CALIFA has been approved in December 2012. It will be shortly available for public at the R3B and CALIFA web-sites, http://www.igfae.usc.es/ r3b

[2] A separated paper for the mechanical design of CALIFA is submitted, same author-list.

[3] R3B, A next generation experimental setup for studies of Reactions with Relativistic Radioactive Beams, http://www.gsi.de/r3b
FAIR, An International Facility for Antiproton and Ion Research, http://www.fair-center.eu

[4] ANSYS, http://www.ansys.com

[5] Nucl. Inst. Meth. B, vol. 266, pp. 46164620, 2008.

[6] GSI, GSI Helmholtzzentrum für Schwerionenforschung GmbH

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SCRIT Electron Scattering Facility at RIKEN

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The SCRIT (Self-Confining Radioactive isotope Ion Target) method has already been confirmed that it can be used for electron scattering experiment for short-lived nuclei [1][2]. An electron scattering facility, which consists of a microtron type electron accelerator (RTM: Racetrack Microtron), an electron storage ring (SR2: SCRIT-equipped RIKEN Storage Ring) and an ISOL (Isotope Separator Online) involving an RI generator, had already been constructed in 2010 at RIKEN Nishina Center to realize electron scattering experiments for short-lived nuclei with SCRIT technique [3].

Ions of stable nuclei, ^{133}Cs and ^{132}Xe, were used as targets to evaluate the performance of this facility. In the testing experiment, the energy of electron beam was set to 150 MeV. The stored electron beam current was ~250 mA with lifetime ~200 minutes. To determine the achievable luminosity, elastically scattered electrons were measured by a detection system, which consists of a drift chamber, plastic scintillation detectors and two calorimeters. The trajectories and energy of scattered electrons were determined by the drift chamber and two calorimeters. The detector system covers the scattering angle from 25 to 50 degree. From the vertex distribution and energy loss in the calorimeters of scattered electrons, the number of elastic scattered electrons from target ions was obtained and the luminosity was determined to be nearly 10^{27}cm^{-2}s^{-1} at beam current 200 mA, which is the required luminosity to determine the charge density distribution of the target nucleus. The Day One experiment will be elastic electron scattering for short-lived Sn isotopes including a doubly magic nuclei ^{132}Sn in the year 2014.

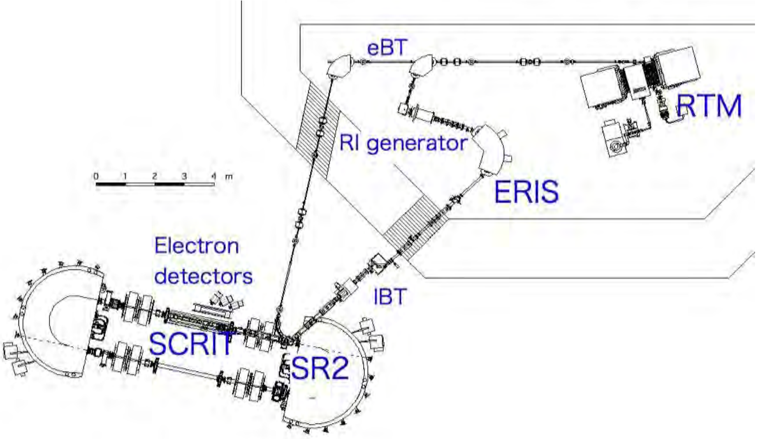

Figure 1: *SCRIT Electron Scattering Faciltiy.*

[1] M. Wakasugi et al.: Phys. Rev. Lett. **100**, 164801 (2008).
[2] T. Suda et al.: Phys. Rev. Lett. **102**, 102501 (2009).
[3] M. Wakasugi et al.: RIKEN Accel. Prog. Rep. **43**, (2010) P.1.

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Polarization of a stored beam by spin-filtering

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Polarized antiprotons allow unique access to a number of fundamental physics observables. Amongst others, the transversity distribution of the valence quarks in the proton would be directly measurable in an unique way through Drell-Yan events generated in double polarized proton-antiproton annihilation [1]. The transversity is the most elusive leading order spin-distribution function of the nucleon. This and a multitude of other findings, which are accessible via $\vec{p}\vec{p}$(bar) scattering experiments, led the Polarized Antiproton eXperiments (PAX) collaboration to propose such investigations at the High Energy Storage Ring (HESR) of the Facility for Antiproton and Ion Research (FAIR).

Although a number of methods to provide polarized antiproton beams have been proposed more than 20 years ago [2] and recently reviewed [3], no polarized antiproton beams have been produced so far, with the exception of a low-intensity and low quality, secondary beam from the decay of anti-hyperons that has been realized at Fermilab [4]. Therefore the PAX collaboration is developing a dedicated program to produce a beam of polarized antiprotons.

An initially unpolarized beam of spin-$\frac{1}{2}$ particles in a storage ring can be polarized either by the spin-flipping method or the spin-filtering method. Spin flipping, which is based on the selective reversal of the spin of particles in one spin state, has the advantage of polarizing the beam without affecting its intensity. However, a previous experiment at COSY by the PAX Collaboration invalidates this technique to polarize a stored antiproton beam by means of the interaction with a co-moving polarized positron beam [5]. Spin filtering can be described as a spin-selective attenuation of the particles circulating in a storage ring [6]. The beam becomes increasingly polarized by repeated interaction with a nuclear polarized internal gas target.

In 2011 the PAX Collaboration has performed a successful spin-filtering test using protons at $T_p = 49.3\,\mathrm{MeV}$ at the COSY ring, which confirms that spin filtering is a viable method to polarize a stored beam and that the present interpretation of the mechanism in terms of the proton-proton interaction is correct. The equipment and procedures to produce stored polarized beams was successfully commissioned and are established. Prior to the presented test, this method was only once shown to work in an experiment performed by the FILTEX group at the TSR ring in Heidelberg in 1992 [7], which exploited spin-filtering on a 23-MeV stored proton beam, in the presence of a polarized atomic hydrogen target.

The results of the spin-filtering experiment at COSY, which is of utmost importance in view of the possible application of the method to polarize a beam of stored antiprotons, will be presented.

[1] P. Lenisa, F. Rathmann for the PAX Collaboration, Technical Proposal for Antiproton-Proton Scattering Experiments with Polarization (2005); available from the PAX website http://www.fz-juelich.de/ikp/pax [2] A.D. Krisch, A.M.T. Lin, O. Chamberlain (Eds.), Proceeding of the Workshop on Polarized Antiprotons, Bodega Bay, CA, 1985, AIP Conf. Proc. 145 (1986). [3] D.P. Barber, N. Buttimore, S. Chattopadhyay, G. Court, E. Steffens (Eds.), Proceedings of the International Workshop on Polarized Antiproton Beams, AIP Conf. Proc. (2008). [4] D.P. Grosnick, et al., Nucl. Instrum. Methods A 290, 269 (1990). [5] D. Oellers et al., Phys. Lett. B 674, 269 (2009). [6] P. L. Csonka, Nucl. Instrum. Meth. 63, 247 (1968). [7] F. Rathmann, C. Montag, D. Fick, J. Tonhaeuser, W. Bruckner, H. G. Gaul, M. Grieser and B. Povh *et al.*, Phys. Rev. Lett. 71 1379 (1993).

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Detector tests for DESCANT - a neutron array for TRIUMF-ISAC

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A novel neutron tagging array based upon an array of liquid deuterated scintillators is being developed for the study of neutron-rich systems. The DEuterated SCintillator Array for Neutron Tagging, or DESCANT, will serve as an auxiliary detector for both the TIGRESS and GRIFFIN spectrometers located at TRIUMF's ISAC radioactive ion beam facility. DESCANT is comprised of 70 fully close-packed neutron detectors which subtends a downstream angle of $\theta = 65.5^o$ and covers 92.6% of this solid angle or 1.08π sr.

Liquid organic scintillators have long been used for fast-neutron detection, due to their fast response and the ability to use pulse-shape discrimination to distinguish between neutron and γ-ray interactions. The multiple scattering of neutrons between detectors is commonly dealt with by vetoing signals collected in adjacent detectors. This results in a much-reduced detection efficiency for higher-neutron multiplicity events. Due to the asymmetry in the neutron-deuteron elastic scattering, a definite peak-like structure is observed in the pulse-height spectrum which, when combined with the time-of-flight, can be used to reject multiple-scattered neutrons without rejecting all events from neighbouring detectors.

Results collected from the direct comparison between NE213 and EJ-315, a deuterated scintillator, in identical geometries will be presented, along with the status of our GEANT4 simulations of the array performance.

It is shown that while the light output of the deuterated detectors is lower than for the non-deuterated detector it is possible to detect neutron with energies as low as 60 keV. The PSD capabilities of the deuterated detectors match and surpass those of the normal detector. Their efficiencies are comparable to that of the normal detector at neutron energies above 2 MeV, while below that energy they suffer from the lower n - d scattering cross section. For very low neutron energies ($<$ 200 keV) the efficiency of the deuterated detector increases again, due to its lower noise level, showing the importance of low photomultiplier tube noise for the detection of low-energy-neutrons.

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The Status of RIB Facilities at IMP and Future-Project HIAF

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Increasing new experimental results for high resolution nuclear spectroscopy have been achieved by using RIB facilities at IMP [1-3]. Recent improvements for the two in-flight fragment separators RIBLL1 and RIBLL2, and the experimental storage ring of the HIRFL-CSR accelerator complex [4-6] at IMP are presented, including the newly-developed detector system and instrumentation updates [7-8]. The future project High-Intensity Accelerator Facility (HIAF) for RIB physics, high energy density physics, and electron-ion collisions will be introduced, which is composed of a superconducting heavy-ion linac, a large acceptance superconducting booster ring, multi-functional storage synchrotron rings, and RIB experimental setups. A linac injector is designed to deliver U^{34+} ions up to ~25MeV/u (possible updated to several hundred MeV/u) with a high beam intensity of ~40 pμA by using two superconducting ECR sources. With multi-turn injection, the booster will accumulate and accelerate U^{34+} and U^{76+} ions up to ~1.2 GeV/u and ~3.4 GeV/u with a particle number of $\sim 1\times 10^{11}$ per pulse, respectively. One fragment separator for the RIB physics by using beams from the linac and the second one between the booster and a storage ring for high precision mass measurement are planned. The β-decay beam line and short-lived nuclei-electron collision are also considered at multi-functional storage synchrotron rings. The HIAF project is proposed to begin the construction end of 2014 and start the commissioning in 2019, which will give a possibility to study nuclei at extreme neutron-rich region.

[1] X.L.Tu et al., Phys.Rev.Lett. 106, 112501 (2011);
[2] Y.H.Zhang et al., Phys.Rev.Lett. 109, 102501 (2012);
[3] X. L.Yan et al., ApJ 766, L8(2013);
[4] J.W.Xia et al.,Nucl. Instrum. Meth. A 488, 11(2002);
[5] Z. Sun, et al., Chinese Physics Letters 15, 790 (1998);
[6] Z. Sun, et al., Nucl. Instrum. Meth. A503, 496(2003);
[7] X.L.Tu et al., Nucl. Instrum. Meth. A 654, 213,(2011);
[8]Y.Y.Yang et al., Nucl. Instrum. Meth. A701, 1(2013).

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A control system for the stopping of Rb beams in superfluid helium for nuclear laser spectroscopy of RI atoms

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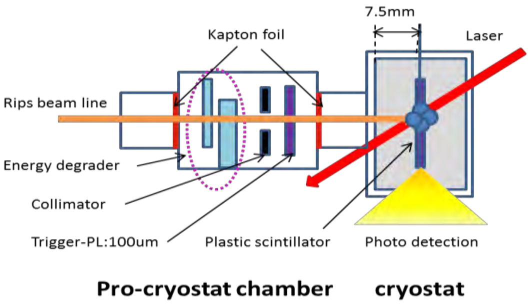
To investigate the structure of exotic nuclei of extremely low yield by measuring nuclear spins and moments, our group developed a new laser spectroscopy technique named "OROCHI abbreviated from "Optical Radioisotope atom Observation in Condensed Helium as Ion-catcher". It is an ingenious combination of optical pumping and double resonance spectroscopy of atoms in He II which have been applied to the studies of nuclear physics in the past few decades[1]. Through years of continuous improvement and off-line experiments for stable atoms, our method have been demonstrated efficient and feasible ablility in the study of low-yield and short-lived various unstable nucleus[2].

In OROCHI experiment, a system mainly comprised of an energy degrader and two plastic scintillators plays a key role to accurately stop the atoms just at the position where the pumping laser passes through. And the system is validated successfully during the on-line experiment with the ^{87}Rb beam. However, based on the calculation of LISE++program with Ziegler's program code [3], we found most of the unstable Rb isotopes produced by the projectile-fragment reactions of ^{85,87}Rb beam can't reach the observation region (max volume: 5 x 2 x 2 mm^3) in He II. After some upgrades of the setup to modify the length of air space to reduce the energy loss, the new experiment has been carried out successfully at RIKEN's accelerator for the ^{84,85}Rb beam. This experiment result is the further evidence for the availability of the control system. In the presentation, details of the system as well as the experimental result will be shown.



[1] B. Tabbert et al.: J. Low. Temp. Phys, 109, 653 (1997).
[2] T. Furukawa et al.: Hyp. Int. 196, 191 (2010).
[3] J.F.Ziegler et al.: Pergamon Press, NY,1985.

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SHELS - Separator for Heavy ELement Spectroscopy. First results.

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In the past, various types of reactions and identification techniques were applied in the investigation of formation cross sections and decay properties of transuranium elements. The fusion - evaporation reactions with heavy targets, recoil - separation techniques and identification of nuclei by the parent -- daughter generic coincidences with the known daughter-nuclei after implantation into position - sensitive detectors were the most successful tools for production and identification of the heaviest elements known presently. This technique may be further improved and presently it may be very promising for the identification of new elements, search for new isotopes and measurement of new decay data for the known nuclei.

Within the past 15 years, the recoil separator VASSILISSA [1] has been used for the investigations of evaporation residues (ERs) produced in heavy ion induced complete fusion reactions. In the course of the experimental work a bulk of data on ERs formation cross sections, synthesized in asymmetric reactions was collected.

With γ and β detector arrays, installed at the focal plane of the VASSILISSA separator, detailed spectroscopy of Fm – Lr isotopes was performed during last 5 years.

In the years 2004 – 2010 using the GABRIELA (**G**amma **A**lpha **B**eta **R**ecoil **I**nvetsigations with the **EL**ectromagnetic **A**nalyser) set-up [2] the experiments aimed to the gamma and electron spectroscopy of the transfermium isotopes, formed at the complete fusion reactions with accelerated heavy ions were performed. Isotopes of No and Lr, synthesized at the ^{48}Ca+^{207,208}Pb→ ^{255,256}No*, ^{48}Ca+^{209}Bi→ ^{257}Lr*, ^{22}Ne + ^{238}U → ^{260}No* reactions were studied. The experiments with high intensity ^{22}Ne beam showed, that for slow evaporation residues rather high (~ 10 %) transmission efficiency need to be obtained. In this case for $\alpha - \gamma$ and $\alpha - \beta$ coincidences used in the study of the isotopes of 104 and 105 elements good statistics could be obtained during one month of the experiment.

Accumulated experience allowed us to perform ion optical calculations and to design the new experimental set up, which will collect the base and best parameters of the existing separators and complex detector systems used at the focal planes of these installations [3].
New experimental set up (SHELS, the velocity filter) on the basis of existing VASSILISSA separator was developed for synthesis and studies of the decay properties of heavy nuclei. Now it is commissioning. In March 2013 first test experiments will be performed. At the focal plane of the separator GABRIELA set up (α, β, γ detectors array) will be installed.

[1] A. Yeremin et, al,. *Phys. At. Nucl.*, **66** (2003) 1042 - 1052
[2] K. Hauschild et. al., *Nucl. Instr. and Meth.,* **A560** (2006) 388-394
[3] A. Yeremin et. al., *Nucl. Instr. and Meth.,* **B266** (2008) 4137-4142

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Design of the multi-reflection time-of-flight mass spectrometer for the RAON facility

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The Rare Isotope Science Project (RISP) for constructing the heavy ion accelerator was launched in Korea in 2011, and the accelerator named RAON is currently under technical design. In the RAON complex, the precise mass measurement facility is expected to be one of the most important facilities, since accurate mass information provides the important key for understanding nuclear structure. The Penning trap is an essential device in the mass measurement facility, and the ion mass can be measured by the Penning trap with accuracy under 10^{-8} for stable nuclei. However, short-lived nuclei with half-lives of few milliseconds have difficulty in mass measurement by the Penning trap, because the Penning trap requires the measurement time over 10 ms. Therefore, the multi-reflection time-of-flight mass spectrometer (MR-TOF-MS), which requires small measurement time below several milliseconds, is adequate for the mass measurement of the short-lived nuclei. In addition, MR-TOF-MS will serve as an isobar separator for highly-charged ions[1, 2].

The MR-TOF-MS, composed of two electrostatic ion mirrors in combination with einzel lenses, is currently being designed in the RISP, and it will be installed after the RFQ cooler. Ions cooled and bunched in the RFQ cooler are guided into MR-TOF-MS. When the mirror electrode voltages are switched off, ions enter the MR-TOF-MS, and the injected ions are multiple-reflected between two ion mirrors, and then extracted by switching off the mirror voltages. Ions with different masses are temporally separated during hundreds of round trips.

In this research, mirror electrodes of the MR-TOF-MS were designed using the numerical simulation code SIMION (See figure 1). In the MR-TOF-MS, temporal spread due to the initial kinetic energy spread is the most crucial factor influencing the resolving power of the device. At the optimal condition of SIMION simulation, temporal spread due to the initial kinetic energy spread of 10 eV was well compressed, and the resolving power of 10^5 was achieved.

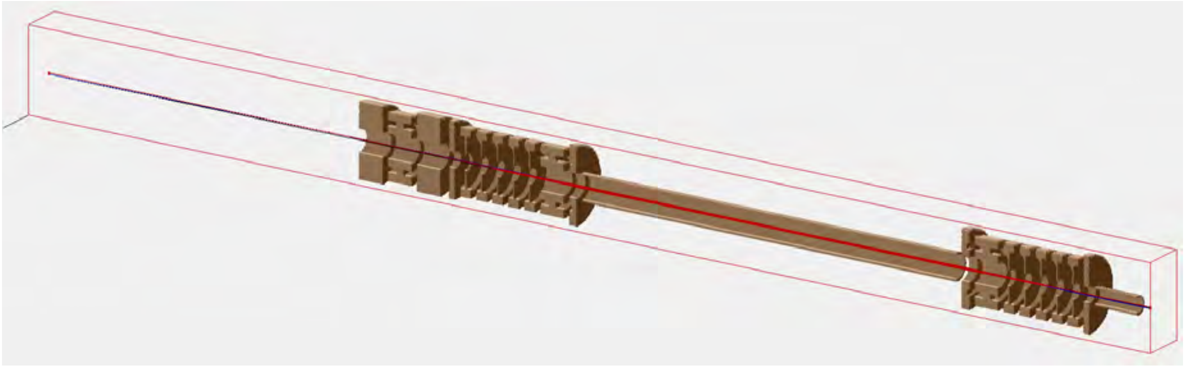

Figure 1: *Ion trajectory and electrodes of the MR-TOF-MS.*

[1] W. R. Plass et al., Nucl. Instrum. Methods Phys. Res., B 266, 4560 (2008).
[2] R. N. Wolf et al., Hyperfine Interact. 199, 115 (2011).

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ELI Nuclear Physics, one of the 4 pillars of ELI, will be built in Bucharest-Magurele, Romania. It is meant as an unique research facility to investigate the impact of very intense electromagnetic radiation on matter, with specific focus on nuclear phenomena and their applications. The extreme light is realized at ELI-NP in two ways: by very high optical laser intensities and by the very intense γ-beam. The High-Power Laser System will consist of two 10 PW lasers, coherently added to get intensities of the order of 10^{23} - 10^{24} W/cm^2. The High Intensity Gamma Beam System, based on Compton backscattering of a high repetition TW-class laser beam on electron bunches accelerated by a warm LINAC, will produce variable energy gamma beam ($E_\gamma = 0.2 – 19.5$ MeV) with a very good bandwidth (in the 10^{-3} domain). This combination allows for stand-alone experiments with a state-of-art high-intensity laser, standalone high resolution γ-beam experiments or combined experiments of both photon sources. The description of the future ELI-NP facility and of the planned experiments will be presented.

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^{8}He Nuclei Stopped in Nuclear Track Emulsion

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A nuclear track emulsion is exposed to a beam of radioactive ^{8}He nuclei with energy of 60 MeV and enrichment of about 80% [1,2]. Measurements of 278 decays of ^{8}He nuclei stopped in the emulsion allow one to evaluate the possibility of α-spectrometry, as well as the first time to observe a thermal drift of atoms ^{8}He in matter. Video collection of decay images taken with a microscope is gathered [3].

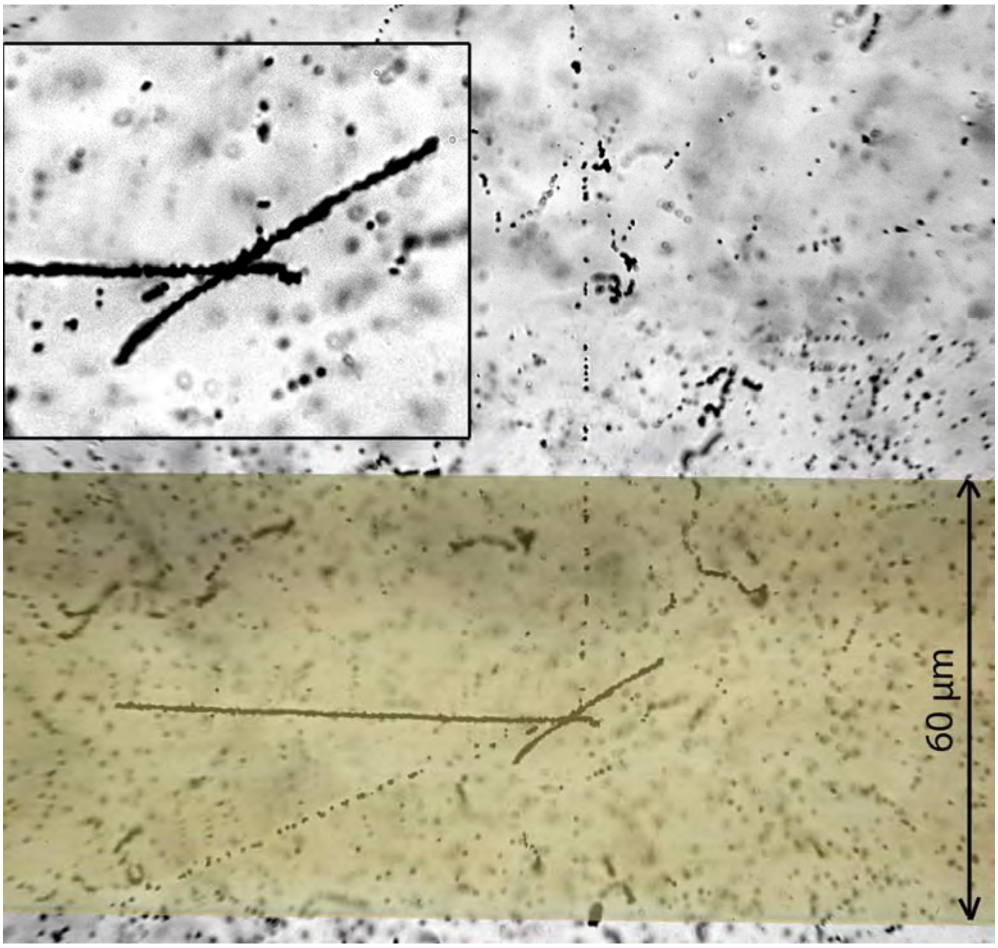

Figure 1: *Macrophotography of hammer-like decay of ^{8}He nucleus stopped in nuclear track emulsion (horizontal track). Pair of relativistic electrons (dotted tracks) and α-particle pair (short back-to-back tracks) are produced. Enlarged decay vertex is presented in the insertion. In order to illustrate the decay image is superimposed with photo of a 60 µm human hair.*

[1] Rodin A. M. et al., Nucl. Instr. & Meth. B, 204, 114(2003).
[2] The ACCULINNA Project http://aculina.jinr.ru/
[3] The BECQUEREL Project http://becquerel.jinr.ru/miscellanea/8He/8He.html

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